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Direction de la recherche

Estimation of Lake Vessel Costs for Canadian Export Grain

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Canada

ESTIMATION OF LAKE VESSEL COSTS

FOR CANADIAN EXPORT GRAIN

Prepared for
Research Branch,
Canadian Transport Commission

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PREFACE

The Research Branch has recently undertaken a work program concerned with the costs of transporting grain from Western Canada to various major Canadian ports. The purpose of this research is to develop practical tools which will permit a more complete understanding of the components of the grain handling and transportation system, their individual cost structures and interrelationships. Work has been completed or is in the process of being completed on Rail, Truck, and Elevator cost models.

This study, by Peter Yee in association with the University of Toronto/York University Joint Program in Transportation considers the costs of vessel movements on the Great Lakes/St. Lawrence Seaway route. The costing framework developed herein has been designed to be flexible so that the effects of a changing environment, such as reductions in iron ore backhaul, differing lake vessel types and alternative methods of estimating capital costs, on ownership and operating costs can be incorporated and evaluated. In addition an interactive computer program usable on an IBM PC (or equivalent) has been created permitting virtually an open-ended sensitivity analysis.

This report develops a base case set of assumptions, or scenario which provides a focus for sensitivity analyses. For example, Quebec is chosen as the grain unloading port in the base case routing; this can be changed to Port Cartier or any of four other St. Lawrence ports. Also the capital charges developed in the report are based on the marginal cost of new vessels and a current dollar cost of capital rate. Should the reader wish to compare shipping costs with those calculated for modal alternatives, such as direct rail to Quebec, the capital base, and rate assumptions chosen can be accomodated using the model.

This working paper is being published to create an awareness of the availability of the model, and as part of the continuing program of communication of Research Branch projects. Comments are welcome, and may be addressed to J. Kruger, A/Chief Bulk Freight Division, at 613-997-6541. Of course, the views expressed herein are attributable to the author, and are not necessarily the views of the Commission or the Government of Canada.

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Responsibility for the views and opinions expressed herein, however, rests with the author and he is solely responsible for any errors and omissions.

Chapter 1
Introduction

1.1 Background

The Great Lakes/St. Lawrence Seaway is one of the most strategic links in the North American transportation system. This water resource, which is shared by Canada and the United States, provides an efficient, and relatively unconstrained passage for Canadian and U.S. grain to deepsea ports in the lower St. Lawrence River, the backhaul of iron ore to steel mills, and the movement of coal and other commodities to the region's major industries. Since the waterway facilitates the transport of raw materials in bulk and at low cost to industry, it contributes to the economic prosperity of the Great Lakes region and of areas beyond. Similarly, the economic health of the waterway is dependent on the economic state of the Great Lakes region and of trading nations abroad.

Lake vessels, ports and the system of locks and canals that constitute the backbone of the waterway system exist in an environment that in the past has been characterized by gradual and secular changes (e.g., the improvement and enlargement of the St. Lawrence Seaway to allow navigation by 222-metre vessels or the discovery of Labrador iron ore and the resulting demand for this commodity by steel mills on the Great Lakes), as well as by unpredictable and sudden changes brought about by the business cycle. For lake vessels, in particular, government regulations on ship safety and labour codes, for instance, and other policies relating to fiscal measures such as depreciation allowances, investment tax credits and shipbuilding subsidies, contribute to an operating environment that is clearly complex.

In more recent years, particularly in the late 1970s, when the economy was strong and the shipping market was buoyant, there was concern over traffic growth and the accompanying capacity increases that would be required at the Welland Canal and in the laker fleet. Most notable was the surge in grain traffic, particularly U.S. export grain, and the expectation of

significant U.S. coal exports to Europe which would flow down the waterway. As the marginal cost of waterway investments is high, it was proper to question whether the traffic build-up being witnessed was a manifestation of long-term trends. Various studies were commissioned by Canadian and U.S. agencies, some to examine the reasons for and causes of these developments as well as the outlook for commodity flows by the turn of the century, while others investigated the requirements for capacity in ports (especially grain terminals) and new vessels in the laker fleet. The completion of these studies was, however, met by an abrupt and serious downturn in the world economy.

The economic recession of 1981-82 severely affected Canadian lake carriers. With declining commodity flows as a result of falling industrial production, particularly iron ore shipments and U.S. grain movements (which were diverted to the Mississippi River because of the absence of congestion on that river), the traffic that once seemed secure could no longer be relied upon. This caused serious financial difficulties for some lake carriers, especially the smaller companies least able to weather the storm, and several left the industry or merged operations with larger companies. Now, with economic recovery at hand, the lake carriers are gradually nursing their industry to health but are still concerned about the long-term prospects and their ability to modernize the fleet.

Following on the heels of economic recovery was the federal government's decision to reform the Crow rate. In the past, this issue has evoked powerful and divided opinions, and the recent debates in the Commons and in the country leading to the passage of the Western Grain Transportation Act of 1984 generated considerable controversy. The new act affects various sectors of the economy, particularly prairie grain producers, domestic agricultural processors and operators of the grain transportation system. Hence, the operating environment of the nation's grain distribution channels will change, and the consequences will be long term. Further, the utilization of the nation's western and eastern grain export routes, of which the Great Lakes/St. Lawrence Seaway is an integral part, will also be affected.

Therefore, it is not clear how the competitiveness of the waterway and the role of lake vessels in the export of Canadian grain will ultimately be affected. At the same time, the future of the waterway also depends on the way its participants, especially the lake carriers, respond to the new environment. Hence, an investigation into the cost of moving Canadian export grain by lake vessels will help to clarify the relationship between the cost of owning and operating lake vessels and the environment in which they operate. This is particularly relevant from the perspective of public policy, because many of the factors that directly or indirectly influence vessel costs are under the purview of the government. Such a study, therefore, is essential to the development of an understanding of the ramifications of the new environment.

1.2 Objectives

This study is concerned with the development of a procedure for estimating the cost of owning and operating lake vessels in the Canadian grain trade. Specifically, the objective is to estimate the cost of transporting Canadian export grain from Thunder Bay to the lower St. Lawrence River ports by modern seaway-sized bulkers and self-unloaders. The cost structure of these vessels is examined and the data required for computing the service costs are collected from lake carriers. The costing framework is developed in sufficient detail to assess the changes in the operating environment and to reflect the effects through the cost of owning and operating the vessel. A sensitivity analysis is also conducted in order to assess the factors that are critical to vessel cost.

1.3 Contents of the Report

This report is organized in seven chapters. Following this introduction, a brief description is provided in Chapter 2 on the grain trade on the Great Lakes/St. Lawrence Seaway. This is not an exhaustive review of the topic, but one which provides a general understanding of the nature and significance of the trade. The third chapter is a detailed description of the methodology employed in estimating vessel cost and discusses the treatment of capital cost, operating cost and voyage cost. Chapter 4 is devoted to the

data base which is required to support the costing procedure. In Chapter 5, the results on the cost of transporting grain (and iron ore) for each of the selected vessels and routes are presented. Chapter 6 takes the analysis further by conducting a sensitivity analysis of the major factors influencing costs, particularly those that are subject to change by government policy or economic conditions. Finally, the report concludes with a set of findings in Chapter 7. Two appendices are also included, and they contain the detailed results of the analysis as well as a description of the computerized vessel costing model developed in this study.

Chapter 2
Canadian Grain Trade on the Great Lakes/St. Lawrence Seaway

2.1 Grain Flows

Canada and the United States use the Great Lakes/St. Lawrence Seaway as an export route to world grain markets. However, the use of this resource in relation to grain transportation is quite different between the two countries. For Canada, the waterway represents a critical link in the eastern route which constitutes one of the nation's two principal grain distribution channels (the second being the western rail route to British Columbia ports). The United States, on the other hand, regards the waterway as an alternative to the Mississippi River with connecting ports in the Gulf of Mexico and the direct routes by rail to U.S. Pacific and Atlantic ports. One consequence of this different perspective on the waterway is that Canadian grain traffic has been more stable than U.S. grain traffic. This is illustrated most clearly in recent years when U.S. grain which had been moved on the Seaway was diverted to the Mississippi River. This diversion was largely the result of the economic recession which freed up capacity on the Mississippi and allowed U.S. grain traffic an unconstrained passage to ports in the Gulf. Thus, the Great Lakes/St. Lawrence Seaway is regarded as an overflow route for U.S. grain traffic, whereas for Canadian grain it is regarded as a vital export route. Since this study is concerned with Canadian export grain, the discussion henceforth will exclude U.S. grain flows.

Canadian export grain on the waterway originates from farms in the prairie provinces. From the farms, grain is trucked to a system of primary elevators located at many shipping points along railway lines. Grain is then loaded in both box and hopper cars and assembled into trains for delivery to Thunder Bay (or B.C. ports for the western route). At Thunder Bay, the vast majority of the grain is unloaded onto lake vessels and transported to the lower St. Lawrence River ports (e.g., Montreal, Sorel, Trois Rivieres, Quebec, Baie Comeau and Port Cartier) for transfer to oceangoing vessels.

A small amount of grain from Thunder Bay is also moved by lake vessels to the "Bay Ports" (e.g., Sarnia, Goderich, Owen Sound, Collingwood, Midland and Port McNicoll) for consumption by local industries, and for rail movements during winter months to Halifax and St. John at subsidized "At and East" rates. Ocean-going vessels also receive some grain from Thunder Bay. The types of grains involved in the export trade are principally wheat and barley, but oats, rye, canola and a variety of other grains are also moved. Ontario grains comprising mainly corn, soybeans and wheat are also moved on water, but this is a relatively small amount, although there is some expectation that future production surpluses might increase exports.

Canadian grain traffic has been growing at a relatively stable rate, and this is shown in Exhibit 2.1. During the period 1970 to 1983, Canadian grain traffic moving downbound through the Welland Canal increased from 10 million tonnes in 1970 to 17.1 million tonnes in 1983. In terms of the percentage of total Seaway movement, downbound Canadian grain traffic accounted for about 14 to 30 percent during the period. The long-term outlook continues to be relatively favourable, and in a study commissioned by the St. Lawrence Seaway Authority and the St. Lawrence Seaway Development Corporation in 1982, Canadian export grain traffic on the waterway is predicted to rise to about 21 million tonnes by the year 2000 (Seaway Commodity Flow Forecast: 1980 to 2000, Acres Consulting Services Limited and Data Resources Inc., 1982). More recently, the forecasting work carried out by the Authority has indicated that in the intermediate term (i.e., to 1990) grain tonnage on the Seaway is expected to be in the range of 16 to 18 million tonnes.

2.2 The Backhaul Relationship

The "mainline" grain trade, that is, the downbound movement from Thunder Bay to the lower St. Lawrence ports, is complemented by upbound shipments of Labrador iron ore to steel mills in Hamilton and U.S. ports on Lakes Michigan and Erie. This balancing movement improves the economics of vessel utilization as it reduces the transport cost to both grain and iron ore. If iron ore shipments decline, grain is expected to bear a greater burden of vessel cost and vice versa.

Exhibit 2.1

Canadian Grain Traffic on the Seaway

	Million Tonnes	Percentage of Total Seaway Traffic
1970	10.0	16
1971	11.9	19
1972	11.9	18
1973	10.1	15
1974	8.5	16
1975	11.5	19
1976	10.7	16
1977	12.2	17
1978	12.5	17
1979	10.4	14
1980	14.1	21
1981	13.4	21
1982	15.9	29
1983	17.1	30

Source: **1983 Traffic Report**, St. Lawrence Seaway Authority.

The emergence of iron ore in the balancing movement with grain came with the discovery of rich deposits in the Quebec-Labrador region and the depletion of high-grade ore in the Mesabi range. As the latter was a major source of supply to U.S. steel mills, Labrador ore filled the needs of U.S. steel companies. Since then, a new process for upgrading ore has been developed, making the Mesabi viable once more, and ore from both sources is now used. The shipments of ore from both sources depend greatly on the state of the steel industry as well as institutional factors; the latter is exemplified by the ownership of substantial Labrador ore production capacity by U.S. steel mills.

Seaway statistics in 1975 show 13.2 million tonnes of Labrador ore shipped to Canadian mills in Ontario (mainly Hamilton) and U.S. mills on the upper lakes, while Canadian and U.S. export grain via the lower St. Lawrence accounted for 20.8 million tonnes. These figures translate to an ore/grain ratio of .63. In 1980, total grain tonnage increased to 28.4 million while ore declined to 11 million tonnes. The ratio as a result declined to .39. By 1982 the situation deteriorated in the face of recession. Ore shipments fell to 7.4 million tonnes while total grain shipments declined less steeply to 25.4 million tonnes, and the ore/grain ratio dropped further to .29.

This declining trend is largely attributed to the decline in U.S. steel mills on Lakes Erie and Michigan, where structural changes have been taking place. According to the same study by Acres and DRI, new U.S. steel-producing capacity has been shifting to the southern U.S. instead of the Great Lakes area. At the same time, downbound grain movements, especially Canadian export grain, have been relatively strong. If these trends persist, the ratio of iron ore shipments to grain movements will diminish further in the future.

2.3 Laker Fleet and Grain Vessels

As of December 31, 1983, there were 118 Canadian dry-bulk vessels on the Great Lakes with a combined mid-season cargo capacity of 2.6 million

tonnes. These vessels are owned and operated by ten companies, with the three largest being Canada Steamship Lines Inc., Upper Lakes Shipping Limited and Algoma Central Railway, followed by four moderate-sized companies including Misener Transportation, N.M. Paterson & Sons Limited, Carryore Limited and Halco Inc.

Of the 118 dry-bulk vessels, 83 are bulkers and 35 are self-unloaders. Bulkers and self-loaders differ in several respects, but mainly in the method of cargo unloading. Bulkers are designed with one or more cargo holds along the length of the ship, and cargo is loaded and unloaded by on-shore equipment. The equipment could be an overhead crane with a clam-like bracket for coal or a "leg" with a series of buckets on an endless belt from a grain elevator. The self-unloader, on the other hand, has machinery on board so that cargo can be unloaded without on-shore equipment; loading of cargo, however, is poured from above like the bulker. The unloading equipment is quite elaborate, involving belts which convey cargo to the stern and then to the ship's main deck. On the deck, cargo is transferred to another endless belt which runs the length of a boom for unloading. Bulkers and unloaders in the fleet vary in size with lengths of less than 153 metres to approximately 222.5 metres. The large seaway-sized vessels, that is, 222.5 metres long and 23.0 metres wide, accounted for 73 vessels in the 1983 fleet with 49 of these being bulkers and 24 being self-unloaders. In terms of tonnage, the seaway-sized vessels represented 73% of the fleet.

Statistics indicating the type of lake vessels dedicated to the grain/iron ore trade for the most recent year are not available from published sources. However, a study conducted by Gordon C. Shaw in 1982, entitled A Forecast of the Canadian Dry-Bulk Vessel Requirements on the Great Lakes in 1990, provides information on industry practices for 1979. In the study, grain and iron ore trades on the mainline were found to be served almost entirely by bulkers. Of the 762 voyages made that year, bulkers accounted for 744 voyages, while self-unloaders accounted for 18 voyages. More importantly, 428 of the voyages were made by the full seaway-sized bulkers. Clearly, the full seaway-sized bulkers dominated the

grain trade on the mainline. However, in more recent years, self-unloaders have been serving the mainline grain/iron ore trade with increased frequency. This is partly attributed to the recession where the decline in other dry bulk trades has forced the self-unloaders to seek business in the grain trade. As well, there is concern that ore unloading ports in the U.S. will not maintain on-shore facilities.

Chapter 3
Costing Methodology

3.1 Overview

A number of methodological considerations merit attention in the estimation of vessel cost. As noted earlier, lake vessels involved in the mainline grain trade from Thunder Bay to the lower St. Lawrence ports are comprised of various sizes and vintages. A fundamental decision has to be made as to whether the cost of vessels should represent the average for the grain laker fleet (assuming that such a fleet is definable), or for those vessels that are most likely to serve future incremental traffic. This is particularly important where the cost estimation of equipment is concerned. Measuring the cost for the fleet would require estimating the cost for each size and vintage of vessel and weighting the costs to arrive at an average. Where scrappage and additions to the fleet also occur, as would normally be the case, changes in the fleet would have to be taken into account. Alternatively, measuring the cost of vessels serving the incremental grain traffic would require calculating the cost of those vessels required for the new traffic and assigning that cost to the traffic. In other words, the choice is between the average cost for the fleet or the marginal cost of the fleet. Since the primary concern is the cost of transporting incremental grain traffic in the new operating environment, marginal costing would be the more useful approach.

Another reason for using marginal cost is that the approach focuses on those ships that are the most modern and efficient of the fleet. This is because ships required for incremental traffic would be the new and efficient vessels. Also, as the current fleet ages and vessels are scrapped, future replacements would be technologically closer to the modern vessels rather than old ones in the existing fleet.

In analyzing vessel cost, the difference between cost and rate should be acknowledged. In this instance, cost would represent all of the resources

employed by the lake carrier to produce the unit of output, that is, the vessel's long-run average cost. This measure of cost would also represent the amount which the carrier must secure in the longer term in order to remain financially viable and to earn a commensurate return on investment. Rates, on the other hand, would reflect competitive forces in the shipping market which are dictated by the demand for and supply of vessels, and at times by factors such as the availability of spot backhaul, age or condition of the vessel, and the institutional links between the carrier and the shipper. However, the rates paid by shippers in the short term may not equal or even necessarily be proportional to the actual costs incurred by the carrier. In the longer term where rates sufficiently approximate the long-run average cost, the carrier would reach his financial objectives. Long-run average cost, therefore, will provide a better measure of the transport cost over the longer term.

In estimating the cost of lake vessels, several empirical methods are available. At least two fundamentally different approaches can be distinguished in this instance: one based on statistical inference and the other on traditional procedures of cost accounting. Statistical procedures have particular applicability when the direct observation of cost-quantity relationships is difficult, that is, when such operations are characterized by many jointly used facilities and high fixed costs. In contrast, cost accounting is particularly feasible when the cost-output relationships are directly observable. As the cost elements in this instance are directly associated with the operating unit, the lake vessel, cost accounting is more appropriate than statistical procedures.

The application of cost accounting to determine vessel cost requires accurate and reliable data. Since the cost data of vessels are not in the public domain, the only possible source is the lake carriers. It is vitally important, therefore, that the help and cooperation of lake carriers be secured. The decision by major Canadian lake carriers to assist in this study by compiling the requested data made the construction of a detailed data base possible.

The treatment of cost and logistics information for vessels to arrive at a measure of vessel cost per tonne of grain is a more involved process. Essentially, vessel cost is classified into three main components: capital charge, operating cost, and voyage cost. The approach starts with an examination of the structure of each of the cost components, and this is followed by the construction of equations linking the different cost elements to their respective determinants. The cost components are then applied to the selected route(s) in the mainline grain/iron ore trade to arrive at total vessel cost for that voyage. Finally, the cost of the vessel is assigned to grain and iron ore by simple allocation rules. A more detailed explanation of the costing process is provided in subsequent sections.

3.2 Selected Grain Vessels

Grain vessels selected for analysis are the full seaway-sized vessels. As mentioned previously, the lake bulker is the predominant vessel in the grain trade while the self-unloader is less significant. Also, in recent years lake/ocean bulkers and self-unloaders have entered the laker fleet, and they are characterized by their ability to operate in ocean trades during winter. The use of the lake/ocean bulker in the grain trade is a relatively new event, but may signal the start of a visible trend. For the purpose of this analysis, four modern seaway-sized vessels—lake bulker, lake/ocean bulker, lake self-unloader and lake/ocean self-unloader--have been selected for costing.

3.3 Capital Charge

The investment in a new vessel is indisputably one of the most important and critical business decisions that the lake carrier has to make. Once the decision to invest is made, the question arises as to how the capital cost of the vessel should be spread over its operating life so that the original capital plus some margin for the use of that capital can be recovered in full.

To illustrate the method developed for this analysis, consider the situation where the capital expenditure of vessel I is incurred in the year 0 with subsequent inflows of revenue R_t (t = year 1 to n) each year for the

next n years. Consider also that all money streams are measured in current dollars. Further, assume that the residual value of the initial investment is zero at the end of the investment horizon (i.e., in year n) and that the variable cost incurred each year is C_t. Therefore, the cash flow before tax in year t will be $A_t = R_t - C_t$. When taxes are applied, and if no depreciation allowances are permitted, the net cash flow (i.e., net of taxes) can be expressed as $A_t - T_t A_t$ or $(R_t - C_t)(1 - T_t)$; where T_t is the corporation tax rate in year t. However, vessels are permitted under Canadian tax laws to apply depreciation allowances to reduce the taxable income and subsequently the amount of tax paid. Assume for the moment that the lake carrier decides to apply depreciation allowances each year by the amount D_t, then the vessel's taxable income will be $A_t - D_t$ and the amount of tax paid will be $T_t(A_t - D_t)$. The net cash flow (i.e., net of tax) in year t will therefore be $A_t - T_t(A_t - D_t)$.

Under the investment appraisal methods of net present value, yield and annual capital charge, the investment of the vessel will be accepted if the following rules hold:

$$\sum_{t=1}^{t=n} \frac{A_t - T_t(A_t - D_t)}{(1+r)^t} - I = NPV > 0 \qquad (1)$$

$$\sum_{t=1}^{t=n} \frac{A_t - T_t(A_t - D_t)}{(1+r')^t} = I \qquad (2)$$

$$A_t - T_t(A_t - D_t) - \left[\frac{Ir}{(1+r)^n - 1} + Ir\right] = surplus_t \qquad (3)$$

Equation (1) is the net present value method, and the investment is accepted if at the firm's specified cost of capital r, the NPV is positive. Equation (2) is the yield method and the investment is accepted if the internal rate of

return r' exceeds the firm's specified cost of capital r. Equation (3), however, is the annual capital charge method and the investment is accepted if at the firm's specified cost of capital r, the annual net cash flow exceeds the capital charge (i.e., resulting in a $surplus_t$). In simplistic terms, the annual capital charge method, which is also known as the annuity method of discounting, recognizes that there are two costs associated with the use of capital: depreciation and interest on the capital employed. Specifically, the method aims at charging depreciation on a sinking fund basis such that the full capital invested in the vessel will be recovered at the end of the vessel's life; also, interest is charged on the initial capital each year until the end of the investment period. The terms representing depreciation and interest costs in equation (3) are $Ir/((1 + r)^n - 1)$ and Ir respectively.

An important feature of the capital charge method is its relationship with the investment appraisal methods of net present value and yield. It can be shown that the present value of $surplus_t$ discounted at the same cost of capital r as used in equation (1) will equate to NPV, that is:

$$\sum_{t=1}^{t=n} \frac{surplus_t}{(1+r)^t} = NPV \qquad (4)$$

Also, if the same cost of capital as the yield method is used, that is, r', $surplus_t$ will become zero and, hence, NPV in equation (4) will equate to 0. This means that when the cost of capital is r', the annual capital charge method is similar to the net present value and yield methods. The significance of this relationship is that while the capital charge method will lead to the same investment decision as the other two methods of appraisal under specific conditions, it also provides a convenient way of spreading the capital cost annually over the life of the vessel. This is particularly useful because it helps to determine the level of net cash flows to be required each year to cover the capital charge for a given cost of capital. Assuming that the firm specifies the cost of capital to be k, then the algebraic form for this condition is the following:

$$\left[A_t - T_t(A_t - D_t)\right] - \left[\frac{Ik}{(1+k)^n - 1} + Ik\right] = 0 \qquad (5)$$

Equation (5) is obtained by substituting r by k in equation (3). The term $surplus_t$ is reduced to zero and the equation simply states that the annual net cash flows (first term in square brackets) less the annual capital charge (second term in square brackets) will be equal to zero at the specified cost of capital k.

Equation (5) is also key to the computation of the long-run average cost of the vessel, for it represents all of the financial resources employed to produce the vessel's unit of output. The equation takes on clearer meaning when the annual cash flow is substituted by the revenue and cost variables (i.e., $A_t = R_t - C_t$) as shown below:

$$(R_t - C_t) - T_t(R_t - C_t - D_t) - \left[\frac{Ik}{(1+k)^n - 1} + Ik\right] = 0$$

$$R_t = \left[\frac{Ik(1+k)^n}{(1+k)^n - 1} - T_t D_t\right]\left[\frac{1}{1-T_t}\right] + C_t \qquad (6)$$

Equation (6) expresses the revenue required each year as a function of the firm's cost of capital k, price of the vessel I, depreciation allowances D_t, corporate tax rate T_t, and the variable cost C_t which is comprised of the vessel's operating cost OC_t and the voyage cost VC_t. As this expression indicates the level of revenue required in the long run, it also provides guidance on rate setting for vessels, especially those on long-term contracts. In practice, whether the vessel will be able to secure the required freight rates under real conditions will depend on competitive forces in the lake shipping market.

A particularly important variable in Equation (6) is the depreciation allowances D_t. Under Canadian tax laws, lake carriers whose vessels are built and registered in Canada can elect to apply the fast capital cost allowances to write-off the vessel in the first four years of operation at the rate of 1/6, 1/3, 1/3 and 1/6 for each of the respective years. However, this

is only permissible if the lake carrier generates sufficient taxable income. In the situation where the lake carrier's vessels are built overseas or do not generate sufficient taxable income, Canadian tax laws will allow the application of depreciation allowances at the maximum rate of 15% of the undepreciated cost of the vessel each year. This effectively means that the lake carrier will be able to recover his initial capital much more quickly with the fast write-off than he would otherwise, and in terms of Equation (5), D_t will assume values of 0 in year 5 and thereafter. To smooth out the fast capital cost allowances, D_t (t=1 to 4) is discounted to the present day and distributed by the annuity method over the life of the vessel. This is shown as follows:

$$R_t = \left\{\frac{Ik(1+k)^n}{(1+k)^n-1} - \left[\frac{T_1 I}{6(1+k)} + \frac{T_2 I}{3(1+k)^2} + \frac{T_3 I}{3(1+k)^3} + \frac{T_4 I}{6(1+k)^4}\right]\right\} \left[\frac{k(1+k)^n}{(1+k)^n-1}\right] \left\{\frac{1}{1-T_t}\right\} + OC_t + VC_t$$

Assuming that the annual corporate tax rate T_t is not variable, and it takes on the value T (commonly at 50%) then the equation becomes:

$$R_t = \left\{\frac{Ik(1+k)^n}{(1+k)^n-1}\right\} \left\{1 - \frac{T}{6(1+k)} - \frac{T}{3(1+k)^2} - \frac{T}{3(1+k)^3} - \frac{T}{6(1+k)^4}\right\} \left\{\frac{1}{1-T}\right\} + OC_t + VC_t \qquad (7)$$

In the case where the fast depreciation allowances are not applicable, the declining balance method of depreciation allowances being practised by some lake carriers is also included as an alternative. Letting q be the rate of decline, Equation (5) under this condition becomes the following:

$$R_t = \left[\frac{Ik(1+k)^n}{(1+k)^n-1} - Tiq(1-q)^{t-1}\right]\left[\frac{1}{1-T}\right] + OC_t + VC_t \qquad (8)$$

An important clarification is necessary at this point, and it concerns the firm's cost of capital k. Since the money streams are expressed in current dollars, k is expressed in nominal terms. The nominal cost of capital k, in this instance, represents the lake carrier's opportunity cost of capital (i.e., the expected rate of return offered by equivalent risk investments) as well as the side effects of financing the project. One method of measuring k is the weighted cost of capital approach which requires information on the mix regarding debt and equity, the cost of the different sources of capital and the risk associated with the venture. The formula can be stated as follows:

$$k = r_d(1-T)(L/I) + r_e(E/I)$$

where:
- r_d = cost of debt
- T = corporate tax rate
- L = debt capital
- I = capital investment
- r_e = cost of equity
- E = equity capital

The application of this formula in its most rigorous form requires the variables in it to be similar to the firm as a whole. The formula gives the correct cost of capital only for projects that are like the firm undertaking them; that is, the formula works for the "average" project that is neither safer nor riskier than the average of the firm's existing assets. A departure from the "average" project would lead to a decrease or increase in the firm's debt ratio and, hence, a change in the firm's specified cost of capital. This condition becomes a problem when, in the case of the lake carrier, the cost of capital specified for the new vessels is not representative of the firm as a whole. As lake carriers are largely private corporations, which are not

required to reveal financial statements as public companies do, it is not possible to verify whether new investments in vessels would affect the company's debt ratio. If this restrictive condition is not met, the weighted cost of capital obtained from the formula will only be approximately correct.

Finally, it is also important to clarify the interpretation of the term annual capital charge in equations (7) and (8). As discussed previously, the strict definition of annual capital charge at the firm's specified cost of capital k is $Ik(1 + k)^n/((1 + k)^n - 1)$. As this term excludes the tax effects, it would be more convenient for the purpose of illustrating the results of vessel costing to include them with capital charge. The tax-adjusted annual capital charge is, therefore, employed throughout in the computation and presentation of vessel costs.

3.4 Operating Costs

This category accounts for the expenses incurred in manning, maintaining, insuring and managing the vessel. It excludes capital charges, which are discussed above, and cost items such as bunker fuel, Seaway tolls, etc., which are discussed later on under voyage costs. Specifically, operating costs include the following:

- Crew Wages (CW)
- Repairs and Maintenance (RM)
- Stores and Supplies (SS)
- Insurance (IN)
- Administration (AD)

Lake carriers provided these costs for each of the selected types of ships, and they represent practices for the 1983 navigation season. For the purpose of this analysis these costs are normalized to a daily basis. Each of the cost items is the sum of many parts: for instance, Stores and Supplies will include cabin supplies, laundry, mooring cables, chandlery, etc., while Insurance will cover hull and machinery, protection and indemnity, etc.

Using the above cost components, the annual operating cost of the vessel in year t is expressed as:

$$OC_t = \left[(CW)(E_1^t)\right]+\left[(RM)(E_2^t)\right]+\left[(SS)(E_3^t)\right]+\left[(IN)(E_4^t)\right]+\left[(AD)(E_5^t)\right] \quad (9)$$

Note that E_1 to E_5 are nominal cost escalators for the respective operating cost components and the resultant costs are, therefore, expressed in current dollars. Equation (9) is also expressed on a per diem basis by dividing it by the length of the operating season (ONS) as follows:

$$\frac{OC_t}{ONS} = \left[(CW)(E_1^t) + (RM)(E_2^t) + (SS)(E_3^t) + (IN)(E_4^t) + (AD)(E_5^t)\right]\left[\frac{1}{ONS}\right] \quad (10)$$

3.5 Voyage Cost

Voyage cost represents the cost incurred by a vessel in making a voyage exclusive of capital charge and operating costs. It is comprised of four principal components: port charges, seaway tolls, pilotage fees, and fuel costs. Voyage cost is essentially a function of the chosen logistics of the vessel. For the purpose of this study, a voyage is defined as a vessel moving grain downbound from Thunder Bay to one of the lower St. Lawrence grain-unloading ports, combined with a return upbound movement to Thunder Bay. Six grain-unloading ports are included here: Montreal, Sorel, Trois Rivieres, Quebec, Baie Comeau, and Port Cartier. The nature of the backhaul defines three different classes of voyage routing:

1. Grain Shuttle: a voyage having no backhaul. The ship is empty for the entire return movement to Thunder Bay.

2. Canadian Steel Mills Backhaul: a voyage having a backhaul of iron ore from one of the lower St. Lawrence iron ore-loading ports (Port Cartier, Pointe Noire, or Sept-Iles) for unloading at Canadian steel mills in Hamilton before proceeding empty to Thunder Bay.

3. U.S. Steel Mills Backhaul: a voyage having a backhaul of iron ore from one of the lower St. Lawrence iron ore-loading ports to one of the U.S. iron ore-unloading ports on the lower Great Lakes

(Buffalo, Ashtabula, Cleveland, Chicago, or Detroit) before proceeding empty to Thunder Bay.

In view of the different ports of call a vessel may make, a set of reference ports is assumed for each of the three voyage routing classes as follows:

1. Grain Shuttle: Thunder Bay - Quebec - Thunder Bay
2. Canadian Mills Backhaul: Thunder Bay - Quebec - Sept-Iles - Hamilton -Thunder Bay
3. U.S. Mills Backhaul: Thunder Bay - Quebec-Sept-Iles -Cleveland - Thunder Bay

These routings constitute the base case, but alternative ports can be selected where necessary. In this particular instance, Quebec has been selected as the grain-unloading port for all three routes because it is a busy grain port and because of its geographic location, rather than for any other consideration (e.g., relatively larger grain tonnage handled at Port Cartier, etc.). As Quebec is located between the upriver grain port of Montreal and the downriver grain port of Port Cartier, Quebec is assumed to be a representative port of call for unloading grain in the lower St. Lawrence River. The base case routes are, therefore, used to serve as a benchmark for the comparison of vessel costs.

The basic equation for voyage cost is:

VOYAGE COST = PORT CHARGES + SEAWAY TOLLS + PILOTAGE FEES + FUEL COST

Each of the four principal cost components in the above equation can be further subdivided, and this is discussed below. An overview of voyage logistics is also shown in Exhibit 3.1.

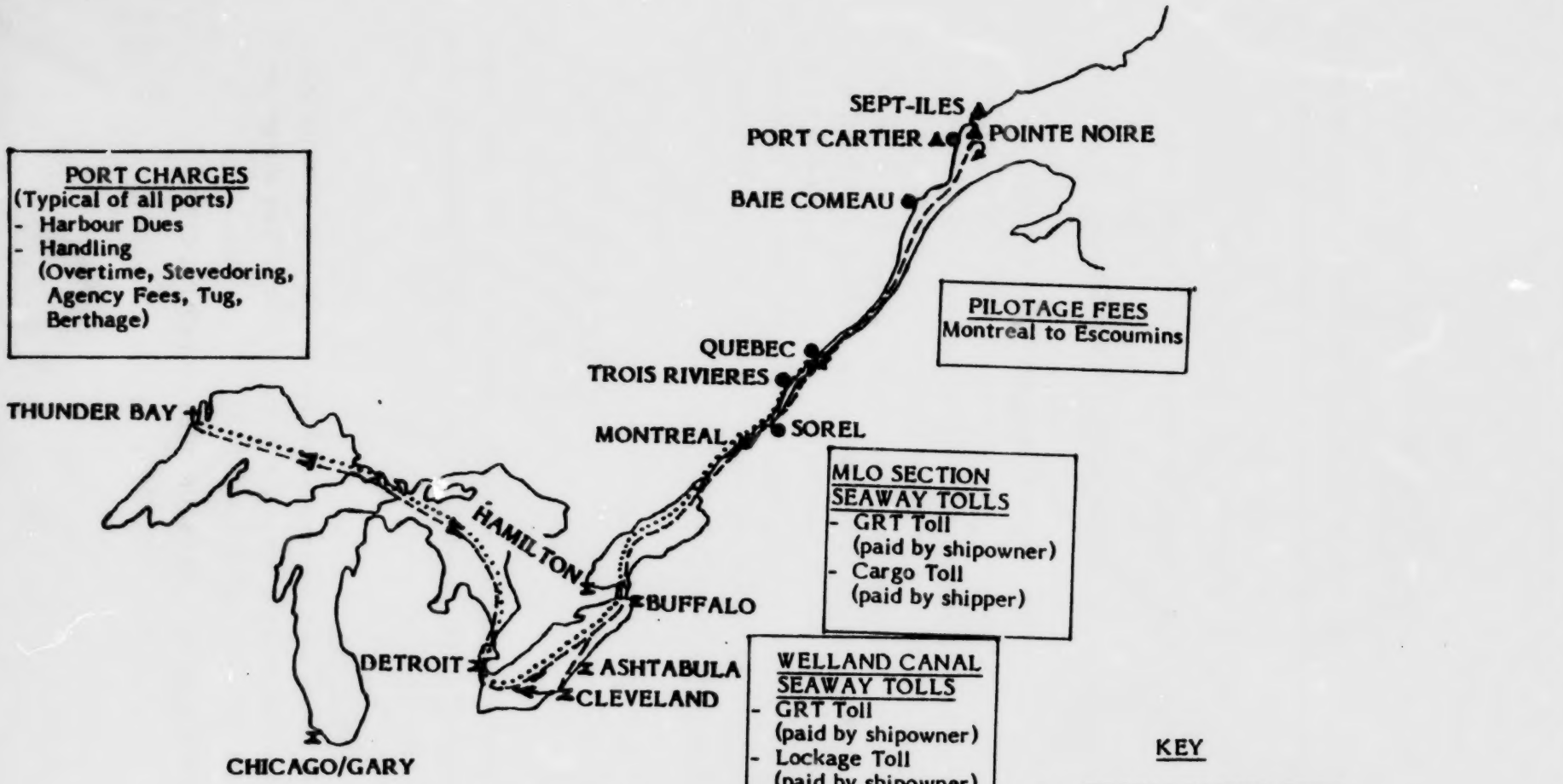
3.5.1 Port Charges

Port charges are those costs incurred by the shipowner while the ship is in port, exclusive of the cost of fuel consumed in port. Port charges are sub-divided into two components, as follows:

PORT CHARGES = HARBOUR DUES + HANDLING COST

Exhibit 3.1

Voyage Logistics



Harbour dues are charges imposed on a vessel when it enters a harbour, applied as a rate per gross registered ton:

$$\text{HARBOUR DUES} = (h_i + h_j + h_k + h_l)\text{GRT}$$

where:

$h_{i,j,k,l}$ = Harbour charges per gross registered ton at ports i, j, k and l

GRT = Gross registered tonnage of vessel

Harbour dues are currently applied only at some of the grain and ore ports on the mainline grain/iron ore routes. For the Canadian ports, harbour dues are applied at those ports designated as either National Harbours (Montreal, Trois Rivieres, Quebec and Sept-Iles) or Public Harbours (Sorel, Baie Comeau and Pointe Noire). No harbour dues are charged at the U.S. iron ore-unloading ports.

Handling is a catch-all term which represents the charges imposed on the shipowner for services associated with the loading/unloading of a vessel when in port. Such charges cover the following items: port agency, stevedoring at Thunder Bay, elevator overtime at Thunder Bay, berthage, and towing. The exact cost of handling for a given voyage will depend on the size of the vessel and on the particular private grain elevators and ore docks chosen for loading and unloading, each of which will have a different fee schedule. A highly structured cost formula for handling has not been developed, so handling cost enters the computation as a simple average value for the type of routing chosen, i.e., grain shuttle or iron ore backhaul. As will be seen later, this is not an exceedingly large item.

3.5.2 Seaway Tolls

Seaway tolls for transit of the Welland Canal and the Montreal-Lake Ontario (MLO) section are paid by the shipowner and shipper to the St. Lawrence Seaway Authority. Seaway tolls are comprised of GRT tolls, cargo tolls, and lockage fees. Currently, the shipowner pays the GRT tolls and lockage fees, while the shipper pays the cargo tolls. The GRT tolls are charges applied to the gross registered tonnage of the transiting vessel. The

cargo tolls are charges applied to the tonnage of cargo carried by the vessel, and the tolls vary with the type of cargo. GRT and cargo tolls are applied on each of the Welland and MLO sections. Lockage fees, on the other hand, are applied only on the Welland. The lockage fee is currently structured as one flat rate per lock transited for a loaded ship and a lower flat rate per lock for a ship in ballast. There are eight locks on the Welland Canal.

The total seaway tolls for a given voyage vary with the size and capacity of the vessel. For a given vessel and grain load, the total seaway tolls depend on whether or not there is an iron ore backhaul. Considering the grain shuttle, the total seaway tolls for one voyage can be calculated using the following equation:

Seaway Tolls = GRT Tolls + Cargo Tolls + Lockage Tolls

GRT Tolls = $2(GRT_w + GRT_{MLO})GRT$

Cargo Tolls = $(CARGO_{gw} + CARGO_{gMLO})$GRAIN TONNES

Lockage Fees = 8(LOCK LOADED + LOCK EMPTY)

where:

GRT_w, GRT_{MLO} = GRT Toll on Welland and MLO sections, respectively ($/gross registered ton)

GRT = Gross registered tonnage of vessel

$CARGO_{gw}$ = Cargo toll on grain on Welland Canal ($/tonne)

$CARGO_{gMLO}$ = Cargo toll on grain on MLO Section ($/tonne)

GRAIN TONNES = Tonnes of grain carried downbound

LOCK LOADED = Charge per lock on Welland Canal for a loaded vessel ($/lock)

LOCK EMPTY = Charge per lock on Welland Canal for a vessel in ballast ($/lock)

For an iron ore backhaul, the total seaway tolls are similarly calculated by including an additional term in the equation for cargo tolls to account for tolls levied on the iron ore cargo.

3.5.3 Pilotage Fees

Pilotage fees are paid by the shipowner to a pilotage authority for the services of a pilot in specified sections of the Great Lakes/St. Lawrence Seaway. The mainline grain movement passes through the jurisdiction of two pilotage authorities: the Great Lakes Pilotage Authority and the Laurentian Pilotage Authority. The Great Lakes Pilotage Authority has jurisdiction throughout the Canadian Great Lakes and on the St. Lawrence River as far downstream as the St. Lambert Lock in Montreal, taking in the entire St. Lawrence Seaway. The Laurentian Pilotage Authority begins its jurisdiction at the St. Lambert Lock and terminates at the Gulf of St. Lawrence. Both jurisdictions have established compulsory pilotage areas. The Great Lakes Pilotage Authority currently exempts Canadian-registered vessels with experienced masters from compulsory pilotage. However, no such exemption is granted by the Laurentian Pilotage Authority. Therefore, Canadian ships must pay the published pilotage fees between Montreal and Les Escoumins, Quebec.

The pilotage fee charged between Montreal and Les Escoumins is a function of two factors: the dimensions of the vessel and the length of time the ship is underway with a licensed pilot aboard. The size of the vessel is measured in terms of a "pilotage unit," and the time under pilotage is measured in terms of a "time factor," as defined below. For the section of the St. Lawrence between Montreal and Quebec, the current pilotage fee is given by:

$$\text{Pilotage fee (\$)} = 13.42PU + 6.46TF$$

where:

PU = Pilotage Unit
= (Breadth of Ship in metres)^2 x (Depth of Ship in metres)

TF = Time Factor
= (Draft of Ship in metres) x (Time in hours that ship is underway under pilot)

Between Quebec and Escoumins, the rates are lower, so that the pilotage charge here is given by:

Pilotage Fees ($) = 9.09 PU + 4.62TF

It is apparent from the above formulae that the pilotage fees incurred during a voyage increase as the voyage proceeds further downriver from Montreal.

3.5.4 Fuel Cost

Bunker fuel is consumed by a vessel during a voyage when it is in port and when it is navigating (although the consumption rate during navigation is about 10 times higher). Fuel cost is, therefore, simply the following:

FUEL COST = FUEL COST IN PORT + FUEL COST IN NAVIGATION

In port, the ship consumes marine diesel, a light fuel, to operate its generator. In navigation, besides consuming additional marine diesel, the ship burns a heavy fuel to power its main engine. This is the typical technology for a newly built vessel. Variations do exist, and for example, some new lake self-unloaders operating on the Great Lakes/Seaway run exclusively on marine diesel. Furthermore, the grade of heavy fuel used to drive main engines differs between particular vessels. In general, the amounts of the two types of fuel consumed in port and navigation by a vessel during a voyage are calculated as:

$$MD_{PORT} = \overline{MD}_{PORT}(PT_i + PT_j + PT_k + PT_l)$$

$$MD_{NAV} = \overline{MD}_{NAV}(\text{Days Navigating})$$

where:

MD_{PORT} = Short Tons of Marine Diesel consumed in port

$\overline{MD}_{PORT}$ = Consumption rate of Marine Diesel in port (Short Tons/day)

$PT_{i,j,k,l}$ = Time in days spent in port of call i, j, k, l

$\overline{MD}_{NAV}$ = Consumption rate of Marine Diesel in navigation (Short tons/day)

MD_{NAV} = Short Tons of Marine Diesel consumed in navigation

$$HEAVY_{NAV} = \overline{HEAVY}_{NAV}(\text{Days Navigating})$$

where:

$HEAVY_{NAV}$ = Short Tons of Heavy Fuel consumed in navigation

$\overline{HEAVY}_{NAV}$ = consumption rate of Heavy Fuel in navigation (Short Tons/day)

The total fuel cost of the voyage is finally expressed as the following:

$$\text{FUEL COST(\$)} = P_{MD}(MD_{PORT} + MD_{NAV}) + P_{HEAVY}(HEAVY_{NAV})$$

where:

P_{MD}, P_{HEAVY} = prices of Marine Diesel and Heavy Fuel in \$/Short Ton.

3.5.5 Transit Times

The methods used to calculate port and navigation times in the above equations require clarification. The time spent by a vessel in a given port is sub-divided into two components: waiting time and loading/unloading time. Waiting time represents the time spent by a vessel standing in the harbour waiting for a berth, shifting between berths, and waiting in the berth for loading/unloading equipment to become available. Observed waiting time in 1983 varies considerably between ports, running on average at 0.7 days. Loading/unloading time is the time during which a vessel is actually being loaded or unloaded (dockworking time), and this is a function of the size of cargo load of the ship and the loading/unloading capacity of the shore-based equipment at the port (and of the vessel's own unloading equipment in the case of a self-unloader).

In equation form the time spent in a given port by a given ship (in days) is calculated as:

PORT TIME = PORT WAITING TIME + CARGO CAPACITY/PORT RATE

where:

CARGO CAPACITY = tonnes of cargo carried by the vessel

PORT RATE = average rate of loading or unloading at the port (tonnes/day)

Navigation time (in days) for a single voyage is calculated using the following expression:

$$\text{Navigation Time} = \text{Distance}_{LW}/V_{LW} + \text{Distance}_{EW}/V_{EW} + 2T_{WELLAND} + 2T_{MLO}$$

where:

Distance_{LW} = distance over which vessel sails loaded in open water (mi.)

Distance_{EW} = distance over which vessel sails empty in open water (mi.)

V_{LW} = speed of vessel sailing loaded in open water (mi./day)

V_{EW} = speed of vessel sailing empty in open water (mi./day)

$T_{WELLAND}$ = time required for a single one-way transit of the Welland Canal (days)

T_{MLO} = time required for a single one-way transit of the Montreal-Lake Ontario Section (days)

In the above definitions, "open water" is taken to include all sections of the mainline grain/ore routes, with the exception of the Welland Canal and the MLO section. In the Welland and MLO, the presence of locks and narrow ship channels or canals imposes low speed limits on vessels such that the transit time is basically independent of a vessel's open water speeds. Therefore, the transit times on the Welland and MLO enter the navigating time equation as simple terms which represent average observed transit times (currently at 0.5 days for the Welland and 1.0 days for the MLO section).

The use of two different open water vessel speeds for loaded and empty movements reflects observed carrier voyage information. This voyage data indicates that vessel operating speeds differ by about 10% between loaded and empty movements in open water, while fuel consumption rates show somewhat less variation between the two conditions. The implication is that many ships are being operated at a consistent engine speed, which results in constant fuel consumption but higher sailing speed for the vessel when in ballast. It is assumed that this practice will not change materially in future and, therefore, the technical relationship between vessel speed and fuel consumption has not been incorporated in the costing formulae.

3.6 Vessel Cost Formulae

Based on the foregoing, the vessel cost formulae can now be stated as follows:

General Formula*:

Vessel Cost = Capital Charge + Operating Cost + Voyage Cost

Vessel Cost Per Voyage V in year t

$$VC_{v,df,t} = \left[\frac{Ik(1+k)^n}{(1+k)^n-1}\right]\left[1 - \frac{T}{6(1+k)} - \frac{T}{3(1+k)^2} - \frac{T}{3(1+k)^3} - \frac{T}{6(1+k)^4}\right]$$

$$\left[\frac{1}{1-T}\right]\left[\frac{VT_{v,t}}{ONS_t}\right] + \left[(CW)(E_1^t) + (RM)(E_2^t) + (SS)(E_3^t)\right.$$

*Capital charge includes adjustment for tax effects.

$$+ \quad (IN)(E_4^t) + (AD)(E_5^t)\Big] \left[\frac{VT_{v,t}}{ONS_t}\right]$$

$$+ \quad HD_{v,t} + HC_{v,t} + ST_{GRT,t} + ST_{v,c,t} + ST_{v,l,t}$$

$$+ \left(a_{v,t}\right)\left(PU\right) + \left(b_{v,t}\right)\left(TF_{v,t}\right)$$

$$+ \quad P_{MD}\left(MD_{v,port} + MD_{v,nav}\right) E^t_{MD}$$

$$+ \left(P_{heavy}\right)\left(Heavy_{v,nav}\right)\left(E^t_{heavy}\right)$$

or

$$VC_{v,ds,t} = \left[\frac{Ik(1+k)^n}{(1+k)^n - 1} - TIq(1-q)^{t-1}\right] \left[\frac{1}{1-T}\right] \left[\frac{VT_v}{ONS_t}\right]$$

$$+ \Big[(CW)(E_1^t) + (RM)(E_2^t) + (SS)(E_3^t)$$

$$+ \quad (IN)(E_4^t) + (AD)(E_5^t)\Big] \left[\frac{VT_{v,t}}{ONS_t}\right]$$

$$+ \quad HD_{v,t} + HC_{v,t} + ST_{GRT,t} + ST_{v,c,t}$$

$$+ \quad ST_{v,l,t} + \left(a_{v,t}\right)\left(PU\right) + \left(b_{v,t}\right)\left(TF_{v,t}\right)$$

$$+ \quad P_{MD}\left(MD_{v,port} + MD_{v,nav}\right) E^t_{MD}$$

$$+ \left(P_{heavy}\right)\left(Heavy_{v,nav}\right)\left(E^t_{heavy}\right)$$

Annual Vessel Cost for Voyage V in Year t

$$AVC_{v,df,t} = VC_{v,df,t} \left[\frac{LNS_t}{VT_{v,t}} \right]$$

or

$$AVC_{v,ds,t} = VC_{v,ds,t} \left[\frac{LNS_t}{VT_{v,t}} \right]$$

where:

$VC_{v,df,t}$ = Vessel Cost for Voyage V with fast depreciation allowances in year t

$VC_{v,ds,t}$ = Vessel Cost for Voyage V with slow depreciation allowances in year t

$AVC_{v,df,t}$ = Annual Vessel Cost for Voyage V with fast depreciation allowances in year t

$AVC_{v,ds,t}$ = Annual Vessel Cost for Voyage V with slow depreciation allowances in year t

I = Purchase Price of the Vessel

k = Weighted Cost of Capital of the firm

q = Declining balance depreciation rate

T_t = Corporation tax rate in year t

$VT_{v,t}$ = Days per Voyage V in year t

ONS_t = Annual Operating days

LNS_t = Lake Navigation Season in year t

CW = Crew Wages in base year

RM = Repairs and Maintenance in base year

SS = Stores and Supplies in base year

IN = Insurance in base year

AD = Administration in base year

$E_{1..5}$ = Cost Escalators for CW, RM, SS, IN and AD, respectively

$HD_{v,t}$ = Harbour dues per Voyage in year t

$HC_{v,t}$ = Handling Cost per Voyage V in year t

$ST_{GRT,t}$ = GRT toll paid by carrier to Seaway Authority

$ST_{v,c,t}$ = Cargo toll paid by shipper to Seaway Authority for Voyage V in year t

$ST_{v,l,t}$ = Lockage fee paid by carrier for Voyage V in year t

PU = Pilotage Unit

TF = Pilotage Time Factor

$a_{v,t}$ = Charge per Pilotage Unit for Voyage V in year t

$b_{v,t}$ = Charge per Time Factor for Voyage V in year t

P_{md} = Price per short ton of marine diesel in base year

P_{heavy} = Price per short ton of heavy fuel in base year

$MD_{v,nav}$ = Marine Diesel consumption in port for Voyage V

$MD_{v,nav}$ = Marine Diesel consumption while navigating in Voyage V

$HEAVY_{v,nav}$ = Heavy Fuel consumption while navigating in voyage V

E_{md} = Marine diesel cost escalator

E_{heavy} = Heavy fuel cost escalator

t = Number of years from the base year

n = Economic life of the vessel

3.7 Cost Allocation Formula

For vessels carrying grain on the shuttle with no backhaul, the full cost of the vessel is assigned to the grain cargo. In the case of the grain/Canadian steel mills and grain/U.S. steel mills, where the backhaul of iron ore is involved, the matter is less straightforward. Industry uses the cost of vessel time as a measure of how its resources are used and, consequently, how to price its services. Therefore, following this practice, vessel cost is assigned to grain or iron ore for the period of time when the vessel is laden with either cargo. Furthermore, when the vessel is empty

and is positioning itself for the next cargo load it assigns its cost to that cargo. Therefore the vessel cost allocation method is formulated as follows:

$$GCT_{v,df,t} = \left[(GTP_v + GTL_v)\ \frac{VC_{v,df,t}}{VT_{v,t}}\right]\left[\frac{1}{VCC}\right]$$

or

$$GCT_{v,ds,t} = \left[(GPT_v + GTL_v)\ \frac{VC_{v,ds,t}}{VT_{v,t}}\right]\left[\frac{1}{VCC}\right]$$

and

$$ICT_{v,df,t} = \left[(ITP_v + ITL_v)\ \frac{VC_{v,df,t}}{VT_{v,t}}\right]\left[\frac{1}{VCC}\right]$$

or

$$ICT_{v,ds,t} = \left[(ITP_v + ITL_v)\ \frac{VC_{v,ds,t}}{VT_{v,t}}\right]\left[\frac{1}{VCC}\right]$$

where:

$GCT_{v,df,t}$	=	Vessel cost per tonne of grain for voyage V with fast depreciation allowances in year t
$GCT_{v,ds,t}$	=	Vessel Cost per tonne of grain for voyage V with slow depreciation allowances in year t.
$ICT_{v,df,t}$	=	Vessel cost per tonne of iron ore for voyage V with fast depreciation allowances in year t.
$ICT_{v,ds,t}$	=	Vessel cost per tonne of iron ore for voyage V with slow depreciation allowances in year t.
GTP_v	=	Vessel time positioning for grain voyage V
GTL	=	Vessel time laden with grain in voyage V
ITP_v	=	Vessel time positioning for iron ore
ITL_v	=	Vessel time laden with iron ore
VCC	=	Cargo capacity of vessel

$VC_{v,df,t}$ = Vessel cost for voyage V with fast depreciation allowances in year t.

$VC_{v,ds,t}$ = Vessel cost for voyage V with slow depreciation allowances in year t

$VT_{v,t}$ = Days per voyage in voyage t

Chapter 4
Data Base

4.1 Information Sources

The three lake carriers--Algoma Central Railway, Canada Steamship Lines Limited and Misener Transportation--were the primary sources of information for the study. The data were compiled for each specific type of vessel by the lake carriers, and these were subsequently aggregated according to vessel type to represent industry practices for the lake bulker, lake/ocean bulker, lake self-unloader and lake/ocean self-unloader participating in the Canadian grain trade.

Other sources from published and private material also supported the data base. These include Greenwood's Guide to Great Lakes Shipping, Canadian Ports and Seaway Directory, and Gordon C. Shaw's 1979 Dry-Bulk Fleet Data Base.

4.2 Data Base

The data is based on 1983 information for the four types of modern vessels selected for analysis. It is organized into seven components as follows:

- Vessel Dimension and Performance
- Purchase Price and Financial Information
- 1983 Annual Operating Cost
- Voyage Routings
- 1983 Port Characteristics
- 1983 Seaway Tolls and Pilotage Rates
- 1983 Handling Costs and Fuel Prices

The details are shown in Exhibits 4.1 to 4.7. It should be noted that in Exhibit 4.2, a distinction is made between domestic construction and overseas construction for the lake/ocean bulker. This distinction is made in order to illustrate the differences in the cost of purchasing and financing

vessels built in Canada and overseas. The data presented are based on two actual lake/ocean bulkers supplied by the lake carriers. However, the two vessels are not identical and therefore, some precision will be lost in the cost comparison of lake/ocean vessels.

Exhibit 4.1

Vessel Dimension and Performance

	Bulker		Self-Unloader	
	Lake	Lake/Ocean	Lake	Lake/Ocean
Principal Dimension:				
- Length Overall (Metres)	222.5	222.5	222.5	222.5
- Breadth Moulded (Metres)	23.0	23.0	23.0	23.2
- Depth Moulded (Metres)	12.8	14.6	14.2	15.2
Draft:				
- Midsummer Draft (Metres)	7.92	7.92	7.92	7.92
- Ballast Draft (Metres)	6.00	6.00	6.00	6.00
Capacity:				
- Gross Registered Ton	20,200	21,500	22,600	24,700
- Cargo Capacity (Tonnes)	27,500	24,800	26,300	24,800
Operating Speeds:				
- Loaded in Open Water (Knots)	10.5	11.5	10.5	10.5
- Ballast in Open Water (Knots)	11.5	12.0	12.0	12.0
Rate of Self-Unloading (Tonnes/h)	-	-	5,000	5,000
Fuel Consumption Rates (Tonnes/Day):				
- Marine Diesel in Port	1.9	2.5	2.0	2.3
- Marine Diesel in Navigation	4.9	2.5	20.3	2.3
- Marine Diesel when Self-Unloading	-	-	8.0	8.0
- Heavy Fuel in Navigation	13.5	19.5	-	20.0
Crew Complement	24	22	28	29
Annual Operating Days	260	360	260	360

Exhibit 4.2

1983 Vessel Purchase Price and Financial Information

	Bulker		Self-Unloader	
	Lake	Lake/Ocean	Lake	Lake/Ocean
Purchase Price:				
• Domestic Construction[1]	$ 29,000,000	$ 30,000,000	$ 36,000,000	$ 39,000,000
or				
• Overseas Construction[2]	-	$ 42,500,000		
Financing Arrangement:[3]				
• Domestic Construction				
- % Financed by Debt	80%	80%	80%	80%
- % Financed by Equity	20%	20%	20%	20%
- Cost of Debt	Prime Rate + 1%	Prime Rate + 1%	Prime Rate + 1%	Prime Rate + 1%
- Cost of Equity	18% p.a.	18% p.a.	18% p.a.	18% p.a.
or				
• Overseas Construction				
- % Financed by Overseas Debt	-	80%	-	-
- % Financed by Equity Domestic Debt	-	20%	-	-
- Cost of Overseas Debt	-	8½% p.a. over 8 years	-	-
- Cost of Domestic Debt	-	9% p.a.	-	-
Capital Cost Allowance:				
• Domestic Construction	Fast CCA or Declining Balance	Fast CCA or Declining Balance	Fast CCA or Declining Balance	Fast CCA or Declining Balance
or				
• Overseas Construction	-	Declining Balance		-
Expected Rate of Return on Capital After Tax	9%-12%	9%-12%	9%-12%	9%-12%
Corporate Tax Rate	50%	50%	50%	50%
Economic Life	25 years	25 years	25 years	25 years

1. Net of shipbuilding subsidies of 20 percent.
2. No import duties.
3. Cost of equity of 18 percent represents carriers' equity cost for average investments.

Exhibit 4.3

1983 Annual Operating Cost

	Bulker		Self-Unloader	
	Lake	Lake/Ocean	Lake	Lake/Ocean
Crew Wages	$1,092,000	$1,386,000	$1,274,000	$1,825,200
Repairs & Maintenance	403,000	594,000	442,000	648,000
Stores & Supplies	156,000	234,000	195,000	288,000
Administration	208,000	223,000	221,000	244,800
Insurance	286,000	378,000	338,000	450,000
TOTAL	$2,145,000	$2,815,000	$2,470,000	$3,455,000
Annual Operating Days	260	360	260	360
Operating Cost Per Day	$ 8,250	$ 7,819	$ 9,500	$ 9,600

Exhibit 4.4

Voyage Routings
Base Case and Alternatives*

	Voyage Type		
	Grain Shuttle	Canadian Mills Backhaul	U.S. Mills Backhaul
Grain-Loading Port	Thunder Bay	Thunder Bay	Thunder Bay
Grain-Unloading Port	Quebec (Montreal, Sorel Trois Rivieres Baie Comeau Port Cartier)	Quebec (Montreal, Sorel Trois Rivieres Baie Comeau Port Cartier)	Quebec (Montreal, Sorel Trois Rivieres Baie Comeau Port Cartier)
Iron Ore-Loading Port	-	Sept-Iles (Port Cartier Pointe Noire)	Sept-Iles (Port Cartier Pointe Noire)
Iron Ore-Unloading Port	-	Hamilton	Cleveland (Buffalo Ashtabula Chicago Detroit)

*Ports in brackets represent alternatives to the base case for the different routings.

Exhibit 4.5

1983 Port Times and Charges

Port Name and Type	Harbour Dues ($/Gross Registered Ton)	Average Waiting Time (Days)	Average Loading/Unloading Rate (Tonnes/h)
Grain Loading (I)			
Thunder Bay	0	0.95	1500
Grain Unloading (J)			
Montreal	0.0184	2.00	1800
Sorel	0.0334	1.20	1100
Trois Rivieres	0.0184	1.50	1300
Quebec	0.0184	0.85	1500
Baie Comeau	0.0334	0.90	1400
Port Cartier	0	0.70	1600
Iron Ore Loading (K)			
Port Cartier	0	0.50	4000
Pointe Noire	0.0334	0.30	4300
Sept-Iles	0.0184	0.90	3300
Iron Ore Unloading (L)			
Hamilton	0	0.25	1150
Buffalo	0	0.20	0*
Ashtabula	0	0.35	2500
Cleveland	0	0.15	3400
Chicago	0	0.10	2000
Detroit	0	0.20	1000

*Buffalo has no shore-based unloading equipment for iron ore (requires self-unloaders).

Exhibit 4.6

1983 Seaway Tolls and Pilotage Rates

Seaway Tolls	
Welland Canal	
• GRT ($/gross reg. ton)	0.07
• Grain Cargo ($/tonne)	0.31
• Ore Cargo ($/tonne)	0.31
• Lockage with Cargo ($/lock)	250.00
• Lockage in Ballast ($/lock)	187.50
MLO Section	
• GRT ($/gross reg. ton)	0.08
• Grain Cargo ($/tonne)	0.52
• Ore Cargo ($/tonne)	0.85
Pilotage Rates (Compulsory Pilotage)	
Montreal-Quebec	
• Pilotage Unit Charge ($/Pilotage Unit)	13.42
• Time Factor Charge ($/Time Factor)	6.46
Quebec-Escoumins	
• Pilotage Unit Charge ($/Pilotage Unit)	9.09
• Time Factor Charge ($/Time Factor)	4.62

Exhibit 4.7

1983 Handling Costs and Fuel Prices

Handling Costs (includes Stevedoring, Elevator Overtime at Thunder Bay, Port Agency Fees, Berthage Charges, Tug Fees)

Average for Grain Shuttle ($/voyage)	=	22,900
Average for Ore Backhaul ($/voyage)	=	26,900

Fuel Prices ($/Short Ton)

• Marine Diesel	=	292.40
• Heavy "Mix" Fuel		
- for lake bulker	=	191.65
- for lake/ocean bulker	=	200.00
- for lake self-unloader	=	191.65
- for lake/ocean self-unloader	=	240.00

Chapter 5
Vessel Cost Estimates for the Grain Trade in 1983

This chapter applies the methods developed in Chapter 3 and the data base described in Chapter 4 to compute vessel costs for the grain trade. Since four types of vessels and three alternative mainline grain voyages have been introduced in the costing methodology, the number of computations for all combinations will be large. Moreover, if some of the input data are changed, the computations will multiply considerably. A computer model has been developed to handle the potentially large amount of computations that may arise. This model is described in an appendix to the report.

Since many combinations of vessel types and voyages are possible, it is practicable to focus on the most essential ones. In this chapter, all four types of vessels will be analyzed for the grain shuttle, grain/Canadian steel mills and grain/U.S. steel mills routes. The ports selected for each of the routes are those defined for the base case. The relevant features of the analysis and results are described below.

5.1 Assumptions

The assumptions and data employed for this analysis are based entirely on information compiled for 1983. The data base has been described in Chapter 4 and is shown in Exhibits 4.1 to 4.7. However, several clarifications are necessary at this point.

First, all vessels are assumed to be built in Canada, and the corporations owning them would be able to generate sufficient cash flows (either from shipping or other corporate ventures) to utilize the fast capital cost allowance. Since the vessels are constructed domestically, they qualify for shipbuilding subsidies. The subsidy rate applicable to these vessels is set

at 20% of the capital cost of the vessel, as the vessels were ordered before July 1, 1980 (vessels ordered after this date qualify for a 9% subsidy and after mid-1985 no subsidy will be in effect).

Second, the weighted cost of capital after tax is estimated at 9.7%, which is within the 9% to 12% expected rate of return on investment after tax reported by the carriers. The calculations are shown in Exhibit 5.1, and the method is based on the weighted cost of capital formula described in Chapter 3. The determinants of weighted cost of capital are derived partly from lake carrier information and partly by judgement. The nominal cost of debt, which is assumed to be 9% per annum, is based on the judgement that short-term interest rates in the long run will eventually decline due to disinflationary forces in the North American economies. This assumes that inflation in the long term will average at 6% per annum and that real interest rates will be 3% per annum. The cost of equity reported by carriers is 18 percent per annum, but this figure reflects the opportunity cost of equity for the company's average investment. As the financing of new vessels are now highly leveraged (i.e., 80% of capital cost of vessel is financed by debt), the risks are expected to be inherently greater. Hence, a risk premium of 70% is judged to be appropriate, and this is applied to obtain a marginal cost of equity of 30.5% for the project. Therefore, the weighted cost of capital after tax is estimated at 9.7% per annum. As illustrated these rates can be altered according to the analyst's perception of financing arrangements. The computer program developed in the study provides the flexibility for changing these assumptions.

Third, the backhaul movement involving iron ore will be fully loaded for each voyage. This is based on the reasoning that the vessel's voyage logistics would be organized to avoid partial loads. Hence, where a vessel is contracted to ship x tonnes of grain and y tonnes of iron ore per year, when $x>y$, the vessel will organize its logistics with a combination of grain shuttle trips (empty backhaul) and fully loaded iron ore backhaul trips to the extent possible.

Exhibit 5.1

Weighted Cost of Capital for Canadian-Built Ships

	Proportion (1)	Nominal Cost before Tax (2)	Tax Rate (3)	Cost after Tax (4)=(3)x(2)	Weighted Cost After Tax (5)=(1)x(4)
Debt	.80	9%	50%	4.5%	3.6%
Equity	.20	30.5%	N/A	30.5%	6.1%
			Weighted Cost of Capital		9.7%

Finally, because the lake/ocean vessels have a 360-day navigation season instead of the Seaway season of 260 days, the cost of owning and operating such vessels on the lakes is prorated. This implies that lake/ocean vessels are expected to earn the required revenue in the ocean trade to cover the full costs associated with winter operations, that is, for the additional 100 operating days.

5.2 1983 Vessel Costs for the Mainline Grain Trade

Vessel costs for 1983 for the mainline grain trade are shown in Exhibits 5.2 to 5.4. These exhibits are summaries of the detailed computations, and they are illustrated as an overview. As can be seen, the number of days required per voyage varies between routes as well as between types of vessels. The shortest voyage is the grain shuttle route with empty backhaul, while the longest voyage is the grain/steel mills route involving iron ore backhaul to either Hamilton or Cleveland. Using the lake bulker as a means of comparison, the vessel would take about 14 days for the grain shuttle and approximately 19 days for the grain/steel mills route. The difference in voyage time is mainly attributed to distance and the number of ports of call. However, the marginal difference in voyage time between vessels on the same route is due to the different operating characteristics of the vessel. For a 260-day Seaway navigation season, the vessels would make about 13 to 15 voyages on the grain/steel mills routes, and about 18 to 19 voyages on the grain shuttle route.

Vessel costs also vary by voyages and by types of vessels. As expected, the vessel cost per voyage is higher for the longer grain/steel mills route than the shorter grain shuttle route with empty backhaul. In the case of the lake bulker, vessel cost is estimated at $426,827 for the grain shuttle trip with iron ore backhaul to Hamilton. Vessel cost differences are also visible between types of vessels on the same voyage. Generally, bulkers have lower vessel costs than self-unloaders, and this is mainly explained by the relatively higher capital cost of self-unloaders where expensive unloading equipment is an essential feature. A further distinction can also be observed in the vessel cost of lake and lake/ocean vessels as the latter has consistently lower costs. For example, in the grain

Exhibit 5.2

Summary of 1983 Vessel Costs for Grain Shuttle Route
(Thunder Bay - Quebec - Thunder Bay)

	Lake Bulker	Canadian-Built Lake/Ocean Bulker	Lake Self-Unloader	Canadian-Built Lake/Ocean Self-Unloader
Per Voyage				
- No. of Days Required	14.0	13.4	13.8	13.7
- Vessel Cost ($)	426,827	360,730	508,977	448,518
Per Seaway Season				
- No. of Voyages	18	19	18	18
- Vessel Cost ($)	7,682,886	6,853,870	9,161,586	8,073,324
Voyage Time Allocation (Days)				
- Grain	14.0	13.4	13.8	13.7
- Iron Ore	0	0	0	0
Cargo Capacity (Tonnes)	27,500	24,800	26,300	24,800
Vessel Cost per Tonne ($)				
- Grain	15.52	14.55	19.35	18.09
- Iron Ore	0	0	0	0

Exhibit 5.3

Summary of 1983 Vessel Costs for Grain/Canadian Steel Mills Route
(Thunder Bay - Quebec - Sept Iles - Hamilton - Thunder Bay)

	Lake Bulker	Canadian-Built Lake/Ocean Bulker	Lake Self-Unloader	Canadian-Built Lake/Ocean Self-Unloader
Per Voyage				
- No. of Days Required	19.0	18.0	17.9	17.9
- Vessel Cost ($)	582,652	488,545	670,936	591,391
Per Seaway Season				
- No. of Voyages	13	14	14	14
- Vessel Cost ($)	7,574,476	6,839,630	9,393,104	8,279,474
Voyage Time Allocation (Days)				
- Grain	12.1	11.5	11.9	11.9
- Iron Ore	6.9	6.5	6.0	6.0
Cargo Capacity (Tonnes)	27,500	24,800	26,300	24,800
Vessel Cost per Tonne ($)				
- Grain	13.56	12.61	16.84	15.74
- Iron Ore	7.63	7.09	8.67	8.11

Exhibit 5.4

Summary of 1983 Vessel Costs for Grain/U.S. Steel Mills Route
(Thunder Bay - Quebec - Sept Iles - Cleveland - Thunder Bay)

	Lake Bulker	Canadian-Built Lake/Ocean Bulker	Lake Self-Unloader	Canadian-Built Lake/Ocean Self-Unloader
Per Voyage				
- No. of Days	18.2	17.2	17.8	17.7
- Vessel Cost ($)	572,327	481,364	675,488	596,016
Per Seaway Season				
- No. of Voyages	14	15	14	14
- Vessel Cost ($)	8,012,574	7,220,458	9,456,832	8,344,224
Voyage Time Allocation (Days)				
- Grain	11.1	10.5	10.9	10.8
- Iron Ore	7.1	6.7	6.9	6.9
Cargo Capacity (Tonnes)	27,500	24,800	26,300	24,800
Vessel Cost per Tonne ($)				
- Grain	12.70	11.84	15.67	14.66
- Iron Ore	8.12	7.57	10.02	9.37

shuttle trip the cost per voyage for the lake/ocean bulker is $360,730 which is lower than the lake bulker at $426,827; similarly, the lake/ocean self-unloader at $448,518 is lower than the lake self-unloader at $508,977. The difference is mainly due to the way annual vessel costs for lake/ocean vessels (with year-round operations of 360 days) have been prorated to the shorter Seaway navigation season. In particular, the annual capital charge for the lake/ocean vessel spread over 360 days, thus making the capital charge associated with seaway navigation lower than the lake vessel operating strictly on 260 days.

The allocation of vessel time and cost to grain and iron ore shipments indicates that grain in all three voyages bears the greatest burden. In the grain shuttle with empty backhaul, grain bears the full cost of the movement. However, grain's share of vessel cost declines when the backhaul movement contains iron ore. Measured on a cost per tonne basis, it can be seen that the cost of moving grain in the shuttle route varies from $14.55 for the bulker to $19.35 for the lake self-unloader. When the vessel is fully loaded with iron ore in the backhaul to steel mills in Hamilton, the cost of moving per tonne of grain falls to a range of $12.61 for the lake/ocean bulker to $16.84 for the lake self-unloader. If the iron ore backhaul is destined for Cleveland instead of Hamilton, the cost of moving per tonne of grain varies from $11.84 for the lake/ocean bulker to $15.67 for the lake self-unloader. Thus, the cost of moving grain downbound is reduced when the backhaul movement is loaded with iron ore.

5.3 Vessel Cost Breakdown and Cost Allocation

Vessel costs summarized in Exhibits 5.2 to 5.4 can be broken down in greater detail to reveal the size and significance of the individual cost items. To simplify the results of the vessel cost breakdown, the lake bulker in the grain/Canadian steel mills voyage is used for the purpose of illustrating the cost breakdown. Exhibit 5.5 shows the individual cost items for the bulker, while Exhibit 5.6 shows similar information on a percentage basis. Capital charge constitutes the most significant cost item, accounting for 47% of the annual total cost of the vessel. This is followed by crew

Exhibit 5.5

Lake Bulker Cost Per Voyage for Grain/Canadian Steel Mills Route
(Thunder Bay-Quebec-Sept-Iles-Hamilton-Thunder Bay = 19.0 days)

	$ 1983 Per Voyage		
Capital Charge			275,178
Operating Cost			156,832
• Crew Wages		79,842	
• Repairs & Maintenance		29,465	
• Stores & Supplies		11,406	
• Administration		15,208	
• Insurance		20,911	
Voyage Cost			150,642
• Port Charges		27,644	
- harbour dues	743		
- handling	26,900		
• Seaway Tolls		55,760	
- cargo	46,200		
- grt	6,060		
- lockage	3,500		
• Pilotage Fees		5,164	
• Bunker Fuel		62,074	
TOTAL			582,652

Exhibit 5.6

Lake Bulker Annual % Cost Distribution for Grain/Canadian Steel Mills Route
(Thunder Bay-Quebec-Sept-Iles-Hamilton-Thunder Bay = 13.0 Voyages)

	1983 Cost in %	
Capital Charge		47
Operating Cost		27
• Crew Wages	13	
• Repairs & Maintenance	5	
• Stores & Supplies	2	
• Administration	2	
• Insurance	4	
Voyage Cost		26
• Port Charges	5	
- harbour dues	*	
- handling	5	
• Seaway Tolls	9	
- cargo	7	
- grt	1	
- lockage	1	
• Pilotage Fees	1	
• Bunker Fuel	11	
TOTAL		100

*Less than one percent

wages, bunker fuel and seaway tolls which account for 13%, 11% and 9% respectively. Also conspicuous is the insignificance of pilotage fees and harbour dues as a percentage of total vessel costs.

The allocation of vessel cost and time to grain and iron ore shipments is shown in Exhibit 5.7. The lake bulker will take 12.1 days for the movement of grain and 6.9 days for the backhaul of iron ore. On this basis, the vessel cost assigned to one tonne of grain and iron ore is $13.56 and $7.63 respectively.

Additional results for other vessels and routes are shown in Exhibits A.1 to A.15 in Appendix A. In general these results show no discernible difference from the trend observed in the lake bulker.

Exhibit 5.7

Lake Bulker Grain/Iron Ore Cost Allocation for Grain/Canadian Steel Mills Route

Port of Call	Grain	Iron Ore
Thunder Bay	1.71 day(s)	
Sailing	5.54 "	
Quebec	1.62 "	
Sailing		1.04 day(s)
Sept-Iles		1.25 "
Sailing		3.34 "
Hamilton		1.25 "
Sailing to Thunder Bay	3.26 "	
Time	12.13 days	6.88 days
% Voyage Time	64%	36%
Vessel Cost Allocation (1983) =	$372,897	$209,795
Vessel Cost Per Tonne (1983) = (cargo capacity = 27,500T)	$13.56	$7.63

Chapter 6
Sensitivity Analysis

This chapter investigates the sensitivity of vessel costs to the operating environment. Capital charge, as indicated in the previous chapter, is the single most important component of vessel cost and, therefore, the effects of the underlying factors are examined. Other cost components, particularly crew wages, bunker fuel and seaway tolls also command attention, although their significance is dwarfed by capital charge. The backhaul movement of iron ore on the mainline grain trade also raises the question of how important this movement is to the economics of vessel utilization for the grain/iron ore trade. While this has been discussed in the previous chapter for the full iron ore backhaul movement, there has been no treatment on the effects of a gradual decline in iron ore movements. In addition, Quebec has been chosen as the grain-unloading port for the base case routes, but an alternative port located in the lower St. Lawrence may affect the cost of moving grain and iron ore, and this is investigated. Also, the relative merit of owning and operating a vessel built overseas as opposed to building it in Canada, in terms of cost, is examined; this may provide some insight into why some lake carriers have preferred to build overseas. Finally, the effects of the general economic environment on vessel cost, particularly as they relate to cost pressures in the economy, are explored.

In order to illustrate the results of the sensitivity analysis clearly, only the bulk vessel is examined as this appears to be the most conventional type of vessel used in the grain trade. To further simplify the interpretation of results, the grain/Canadian steel mills route via Hamilton is selected for the analysis. The results apply to costs in 1983 except in the case where cost escalation is involved.

6.1 Backhaul Considerations

As discussed in the previous chapter, the lake bulker on the grain shuttle would assign all of its long-run average cost to grain, thereby

resulting in a cost per tonne of $15.52. Where iron ore backhaul is involved, the lake bulker has been assumed to be fully loaded in every voyage, although in practice this may not be the case. As Labrador iron ore shipments to Canadian and U.S. steel mills in the short term have a tendency to fluctuate according to business conditions, the relationship between downbound grain shipments and upbound iron ore shipments will not always be equally balanced. Moreover, as Labrador iron ore shipments to the U.S. steel mills are expected to slow down in the long run while Canadian grain traffic is expected to increase, the balancing relationship is expected to deteriorate. Therefore, the impact of different iron ore backhaul relationships on the cost of moving of grain has been calculated. The results are shown in Exhibit 6.1. It is difficult to forecast the most likely backhaul relationship in future, but if the relationship of three downbound grain shipments to every one upbound iron ore backhaul shipment to Hamilton is assumed to be the trend, the cost of moving one tonne of grain will be $14.87. Similarly, if Cleveland is the iron ore-unloading port instead of Hamilton, the cost of moving grain will be $14.58 per tonne.

6.2 Shipbuilding Subsidies

Ships ordered in Canada after July 1980 qualify for subsidies at a rate of 9 percent (prior to this date the subsidy rate was 20 percent). The impact of the reduced subsidy is an increase in the purchase price of the Canadian-built vessel. In the case of the lake bulker, the new building price has been raised from $29 million (based on a shipbuilding subsidy rate of 20%) to $33 million, which is an increase of $4 million to the shipowner. As a result, the capital charge for the lake bulker is also increased. In the case of the lake bulker on the grain/Canadian steel mills route, the capital charge is increased from $275,178 to $313,133 per voyage; this represents a 14% increase. On a percentage cost distribution basis, the new capital charge accounts for 50% of vessel cost as opposed to 47% previously. As a result the cost of moving one tonne of grain is increased from $13.56 (when shipbuilding subsidy was at 20%) to $14.44.

Exhibit 6.1

Lake Bulker Cost Per Tonne of Grain As a Function of the Frequency of Iron Ore Backhaul

Frequency of Iron Ore Backhaul (% of voyages with backhaul)	Weighted Vessel Cost per Tonne of Grain (1983 $)	
	Canadian Steel Mills Backhaul (Hamilton)	U.S. Steel Mills Backhaul (Cleveland)
0 (Grain Shuttle)	15.52	15.52
20	15.13	14.96
33	14.87	14.58
40	14.74	14.39
50	14.54	14.11
60	14.34	13.83
80	13.95	13.26
100 (Backhaul every voyage)	13.56	12.70

By mid-1985, the shipbuilding subsidy will no longer be in effect. Without the subsidy, the lake bulker will cost the shipowner $36.25 million instead of $29 million. The capital charge of the vessel on the same voyage will, therefore, increase from $275,178 to $343,972 representing a gain of 25%. At the same time, the capital charge will now account for 53% of vessel cost. The cost of moving per tonne of grain will increase to $15.15 from the previous estimate of $13.56 when the subsidy was 20%.

6.3 Cost of Debt

The cost of debt has been assumed at 9 percent for the base case computations. This is based on the assumption that short-term interest rates, which peaked in 1981, will continue to decline so that over the 25-year economic life of the vessel, short-term rates will average 9 percent. If inflation returns to levels typical of the late 1970s, then the cost of debt will be much higher than has been assumed. Assuming that the cost of debt in such an environment is 19.75% per annum, then the weighted cost of capital after tax is estimated to be 14% per annum. This estimate is 4.3% per annum higher than the base case weighted cost of capital of 9.7%. Under this environment, the capital charge for the lake bulker on the grain/Canadian steel mills voyage is estimated to increase to $392,515, which is an increase over the base case estimate of $275,178 by 43%. On a cost breakdown basis, capital charge will account for 56 percent of the vessel cost as opposed to 47 percent in the base case. Also, the cost of moving per tonne of grain will increase by 21 percent over the base case to $16.29.

6.4 Financial Leverage

The base case financing arrangement was set at 80 percent debt and 20 percent equity. However, it is not uncommon for lake carriers to finance new vessels entirely by debt. In this situation, the weighted cost of capital net of tax is not easily calculable as it requires judgement on what premium is appropriate for the risks associated with a fully leveraged investment in Great Lakes shipping. It is recalled that in the base case, where 20% of equity was involved, the risk premium was assumed to be 70%.

Since the financing of the vessel is now fully leveraged, the risk premium should be higher. For this reason, the premium for risk-bearing is assumed to be 150% in this analysis. As a result, the weighted cost of capital after tax at a nominal cost of debt of 9% is estimated at 11.25% (i.e., the product of the cost of debt of 9% and the tax rate of 50% factored up by a risk premium of 150%). In other words, the weighted cost of capital after tax of 11.25% reflects a net of tax cost of debt of 4.5% per annum and a premium of 6.75% per annum. Under this financing arrangement, the capital charge of the lake bulker on the grain/Canadian steel mills route is estimated to be $315,870 versus a base case estimate of $275,178. As a percentage of vessel cost the capital charge accounts for 51%. The cost of moving grain is estimated at $14.51 as compared to $13.56 in the base case.

6.5 Depreciation Allowances

The fast capital cost allowance of 1/6, 1/3, 1/3 and 1/6 for each of the four years respectively is commonly acknowledged as one of the most important sources of financing in the lake shipping industry. However, as pointed out previously, this is only advantageous to the financially strong companies with large taxable incomes. Companies without the necessary taxable incomes will not be able to use these allowances. They can, however, elect to write off the cost of the vessel at a rate no faster than 15 percent of the undepreciated cost of the vessel each year. Frequently, this is not even attainable by many carriers and consequently the declining balance method at 4 percent is used instead.

The effect of a slower write-off on the capital cost of the lake bulker is to increase the capital charge. The capital charge on a voyage basis is estimated at $372,351, which is an increase of 35 percent over the base case. As a percentage of vessel cost, capital charge accounts for 55 percent. The effect on vessel cost per tonne is to increase the cost of grain to $15.82 as compared to $13.56 in the base case.

6.6 Overseas Construction

The major advantage in buying overseas vessels for use in the Great Lakes is the attractive financing arrangements. For example, a large part of the capital cost of the vessel can be financed by the host country at low interest rates over a period of time. However, recent legislative changes to import duties on foreign-built vessels, which previously exempted vessels built in Commonwealth shipyards, will now subject all vessels constructed overseas to import duties of 25%. This effectively raises the price of purchasing the overseas-built vessel. Moreover, because the vessel is not built in Canada it will not be entitled to the fast depreciation allowances.

The data employed in evaluating vessel cost under these arrangements is based on the lake/ocean vessel shown in Exhibit 4.2 in Chapter 4. As shown, the new building price to the shipowner is $42.5 million, which is much higher than the cost of either the domestically built lake bulker ($29 m.) or lake/ocean bulker ($30 m.). Also the $42.5 million does not include any import duties as it was ordered and delivered by early 1983. Furthermore, the vessel is financed entirely by debt through overseas and domestic institutions. In estimating the weighted cost of capital net of tax, it has been assumed that after eight years, interest rates would have declined progressively so that the nominal cost of the overseas debt would average 6½ percent over the 25-year economic life of the vessel. For domestic debt, the average nominal cost over the period would be higher at 9 percent. This gives a weighted cost of capital net of tax of 8.75 percent. This is slightly lower than the cost of capital of 9.7 percent estimated for Canadian-built vessels.

Based on these assumptions, it is calculated that the cost of moving grain by the lake/ocean bulker for the grain/Canadian steel mills route is $16.33 per tonne. This estimate is higher than the base case estimate of $13.56 per tonne for the lake bulker. As the calculation is based on the declining balance depreciation allowance, a more comparable estimate is the $15.82 per tonne for moving grain by the lake bulker which employs a similar method of calculating depreciation allowance (see previous section

on depreciation allowances). The cost differential in the latter instance is marginal. In view of the new import duties that are now levied on foreign built vessels, it is expected that the cost differential will widen to favour the Canadian built vessel.

6.7 Alternative Grain-Unloading Port

Quebec has been chosen as the grain-unloading port in the base case routes. To test the sensitivity of an alternative grain-unloading port on the cost of moving grain, Port Cartier is chosen as an alternative in the grain/Canadian steel mills route. Since Port Cartier is located further down the lower St. Lawrence than Quebec is, the vessel time and cost allocated to grain will be higher than in previous routes. The cost of moving grain by the lake bulker is $14.56 per tonne as opposed to $13.56 in the base case (i.e., with Quebec as the grain-unloading port).

6.8 Cost Escalation

Vessel costs will escalate in future. In order to obtain a sense of how these costs are likely to escalate and the impact on the cost of moving grain, the following rates of increase on the individual cost items are assumed over the period 1983-1988:

- Crew Wages - 6% per annum
- Repairs and Maintenance - 8% " "
- Stores and Supplies - 6% " "
- Administration - 6% " "
- Insurance - 8% " "
- Fuel - 4% " "
- Handling costs - 6% " "
- Seaway Tolls - 15% over 5 years
- Pilotage Fees - 15% over 5 years

The above rates reflect an environment of moderate inflation, which is assumed to be around 6% per annum over the next five years. In particular, fuel prices will be subject to the downward pressure in world oil prices and will therefore increase at a rate of 4% per annum, which is lower than

inflation. Also, Seaway tolls and pilotage fees, which are subject to government decisions, are assumed to increase by 15% over the five-year period.

By 1988, the vessel cost per voyage will escalate to $673,212 from the 1983 estimate of $582,652. This represents an increase of about 16%. The cost of moving grain by 1988 will increase to $15.67 per tonne, from the 1983 estimate of $13.56.

6.9 Summary

The results of the sensitivity analysis are summarized in tabular form in Exhibit 6.2. It is seen that, based on the assumptions employed, vessel cost is more sensitive to the cost of debt, choice of Canadian or overseas construction (only when compared to the base case), method of depreciation allowances, shipbuilding subsidy, and cost pressure in the economy than to other factors.

Exhibit 6.2

Summary of Sensitivity Analysis Results

	Base Case[1]	Backhaul Relationship (33% Iron Ore backhaul)	Shipbuilding Subsidy 9%	Shipbuilding Subsidy NIL	Cost of Debt (19.75%)	Financial Leverage (100% Debt)	Declining Balance Allowance[2]	Overseas-Built Lake/Ocean Bulker	Alternative Grain-Unloading Port (Port Cartier)	Cost Escalation to 1988
Capital Charge ($)	275,178	N/A	313,133	343,972	392,515	315,870	372,351	339,215	273,642	275,178
	(47%)		(50%)	(53%)	(56%)	(51%)	(55%)	(54%)	(47%)	(41%)
Operating Cost ($)	156,832	N/A	156,832	156,832	156,832	156,832	156,832	140,863	155,957	216,481
	(27%)		(25%)	(24%)	(22%)	(25%)	(23%)	(22%)	(27%)	(32%)
Voyage Cost ($)	150,642	N/A	150,642	150,642	150,642	150,642	150,642	152,856	150,695	181,553
	(26%)		(24%)	(23%)	(22%)	(24%)	(22%)	(24%)	(26%)	(27%)
Total Vessel Cost ($)	582,652	N/A	620,608	651,447	699,989	623,344	679,825	632,934	580,294	673,212
	(100%)		(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)
Vessel Time Allocation (days)										
Grain	12.13	N/A	12.13	12.13	12.13	12.13	12.13	11.52	12.99	12.13
Iron Ore	6.88	N/A	6.88	6.88	6.88	6.88	6.88	6.50	5.91	6.88
Vessel Cost Per Tonne ($)										
Grain	13.56	14.87	14.44	15.15	16.29	14.51	15.82	16.33	14.56	15.67
Iron Ore	7.63	7.63	8.12	8.53	9.16	8.16	8.90	9.19	6.54	8.81
% Change in Cost per tonne over Base Case										
Grain	-	9.7	6.5	11.8	20.1	7.0	16.7	20.4	7.3	15.5
Iron Ore	-	0	6.5	11.8	20.1	7.0	16.7	20.4	14.3	15.5

[1] Assumes full iron ore backhaul, 20% shipbuilding subsidy rate, 80% financing by debt, 9% cost of debt per annum, fast capital cost allowances, Canadian-built vessel, and Quebec as the grain-unloading port.

[2] 4 percent used.

Chapter 7
Findings

The foregoing chapters have described the costing principles employed in the methodology, the data base obtained from the lake carriers, and the results of the analysis. By way of concluding, this chapter will present the main findings of the investigation.

First, the cost of transporting export grain from Thunder Bay to the lower St. Lawrence River ports by modern seaway-sized vessels is contingent upon many factors, and based on the assumptions employed in this analysis, the 1983 cost is estimated to be in the range of $11.84 to $19.35 per tonne. In general, bulkers are found to be less costly than self-unloaders in the carriage of grain. For example, in the case of the grain shuttle with empty backhaul, the cost per tonne for moving grain by the lake bulker and the lake/ocean bulker is $15.52 and $14.55 respectively, whereas the lake self-unloader and lake/ocean self-unloader will cost $19.35 and $18.09 per tonne.

Second, the impact of the availability of iron ore backhaul shipments on the cost of moving grain is found to yield a cost differential of 14 to 22 percent. This cost differential is based on a comparison of the cost of moving grain by a lake bulker on the grain shuttle route with empty backhaul ($15.52 per tonne of grain) and the cost of moving grain by the same vessel with full iron ore shipment on the backhaul to Hamilton ($13.56 per tonne of grain) or to Cleveland ($12.70 per tonne of grain). As the ratio of iron ore shipments to grain shipments is expected to decline in future, the burden of vessel costs will fall increasingly onto grain. On the assumption that there will be three downbound grain shipments to one iron ore shipment in future, the cost of moving grain will be $14.87 per tonne via Hamilton and $14.58 via Cleveland.

Third, the structure of vessel cost reveals that capital charge is the single largest component of the cost of owning and operating the vessel, as

it accounts for as much as half of the total vessel cost. The next most important items are crew wages, fuel cost, and Seaway tolls (inclusive of cargo tolls paid by shipper), and these account for approximately 13, 11, and 9 percent of total vessel cost respectively. Other cost items, such as repairs and maintenance, stores and supplies, administration, handling cost, and insurance, account for about 2 to 5 percent each while pilotage fees and harbour dues account for a negligible percentage of vessel cost. Clearly, the size of the capital charge dwarfs the other cost components, and this demonstrates the capital intensiveness of the lake shipping business. This also points out quite clearly the critical nature of the underlying factors, such as new building price, financing arrangements, interest rate movements, and capital cost allowances, in determining the capital charge. Similarly, other cost components, while relatively much less significant, are affected by cost pressures in the economy and government policies respecting Seaway tolls, pilotage fees and harbour dues.

Fourth, large changes in the interest rate environment will critically affect the shipowner's cost of capital. The nominal interest rate assumed in the analysis is 9 percent per annum over the life of the vessel. If interest rates are to rise appreciably higher than has been assumed, the impact will be an increase in the capital charge as well the cost of moving grain (and iron ore). At a higher rate of interest of 19 3/4 percent per annum, the cost of moving grain by a lake bulker on the grain/Canadian steel mills route via Hamilton will increase from $13.56 to $16.29 per tonne. This represents a cost increase of 20 percent.

Fifth, the application of depreciation allowances on the vessel to reduce taxes affects the cost of owning and operating the vessel. Where shipowners qualify for the use of the accelerated capital cost allowance, the cost of owning and operating the vessel will be lower than for shipowners who could not qualify; usually shipowners who do not qualify will use the declining balance method to claim the capital cost allowance. Under these alternative arrangements, the cost of moving grain by the lake bulker on the grain/Canadian steel mills route via Hamilton is estimated to be $13.56 per

tonne when the capital cost allowance is accelerated and $15.82 per tonne when the capital cost allowance is applied with the declining balance method at 4 percent. The cost differential is 17 percent.

Sixth, the advantage in buying a vessel from overseas shipyards, instead of Canadian yards, depends on the financial position of the carrier. Buying overseas has particular appeal to carriers who are unable to generate sufficient taxable income to claim the accelerated capital cost allowance. In addition, the attractive financing terms at low interest rates provided by the host country will reduce the financing costs to the carriers. Under this arrangement an overseas-built vessel, such as a lake/ocean bulker, plying the grain/Canadian steel mills (via Hamilton) route is estimated to cost $16.33 per tonne in the movement of grain. If the same shipowner were to purchase a Canadian-built vessel, such as the lake bulker, without the opportunity of a fast write-off and faced with higher financing costs, the cost of moving grain is estimated to be $15.82 per tonne. The cost differential is, therefore, marginal. However, recent legislative changes to import duties, which effectively increase the price of the overseas vessel by 25 percent, may widen the cost differential to favour the Canadian-built vessel.

Seventh, the shipbuilding subsidy has helped lake carriers to reduce vessel costs. Ships ordered prior to July 1980 were entitled to a subsidy rate of 20 percent, but ships ordered after mid-1985 are not entitled to the subsidy. The cost of moving grain on the grain/Canadian steel mills route by a lake bulker with a subsidy rate of 20% is estimated at $13.56 per tonne. Without the subsidy, the cost of moving grain by the same vessel will be $15.15 per tonne. This represents an increase of 12 percent.

Eighth, the impact of vessel cost increases on the cost of moving grain under an environment of moderate inflation of 6 percent per annum is estimated to increase by 16 percent by 1988. The cost of moving grain by the lake bulker on the grain/Canadian steel mills route will increase from the 1983 estimate of $13.56 per tonne to $15.67 by 1988.

Finally, the cost of moving Canadian export grain on the waterway will continue to change in direction and magnitude that may be different from the estimates produced in this study. The changes may be critical or insignificant but it will be highly useful to be aware of the nature of the effects. The vessel costing tool developed in this study will be able to facilitate an understanding of alternative trends in vessel cost under conditions different to those assumed in this investigation.

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Appendix A

VESSEL COSTING RESULTS

Exhibit A.1

Lake Bulker Cost Per Voyage for Grain Shuttle Route
(Thunder Bay-Quebec-Thunder Bay = 14.0 Days)

		$ 1983 Per Voyage	
Capital Charge			203,013
Operating Cost			115,704
• Crew Wages		58,904	
• Repairs & Maintenance		21,738	
• Stores & Supplies		8,415	
• Administration		11,220	
• Insurance		15,427	
Voyage Cost			108,110
• Port Charges		23,272	
- harbour dues	372		
- handling	22,900		
• Seaway Tolls		32,385	
- cargo	22,825		
- grt	6,060		
- lockage	3,500		
• Pilotage Fees		2,962	
• Bunker Fuel		49,491	
TOTAL			426,827

Exhibit A.2

Lake Bulker Annual % Cost Distribution for Grain Shuttle Route
(Thunder Bay-Quebec-Thunder Bay = 18.0 Voyages)

	1983 Cost in %		
CAPITAL CHARGE			48
OPERATING COST			27
• Crew Wages		13	
• Repairs & Maintenance		5	
• Stores & Supplies		2	
• Administration		3	
• Insurance		4	
VOYAGE COST			25
• Port Charges		5	
- harbour dues	*		
- handling	5		
• Seaway Tolls		7	
- cargo	5		
- grt	1		
- lockage	1		
• Pilotage Fees		1	
• Bunker Fuel		12	
TOTAL			100

*Less than one percent

Exhibit A.3

Lake Bulker Grain/Iron Ore Cost Allocation for Grain Shuttle Route

Port of Call		Grain	Iron Ore
Thunder Bay		1.71 day(s)	
Sailing		5.52 "	
Quebec		1.61 "	
Sailing to Thunder Bay		5.17 "	
Time	=	14.02 days	0.00 days
% of Voyage Time	=	100%	0%
Vessel Cost Allocation (1983)	=	$426,827	$ 0
Vessel Cost Per Tonne (1983) (cargo capacity = 27,500T)	=	$15.52	$ 0.00

Exhibit A.4

Lake Bulker Cost Per Voyage for Grain/U.S. Steel Mills Route
(Thunder Bay-Quebec-Sept-Iles-Cleveland-Thunder Bay = 18.2 Days)

	$ 1983 Per Voyage		
Capital Charge			263,318
Operating Cost			150,074
• Crew Wages		76,401	
• Repairs & Maintenance		28,196	
• Stores & Supplies		10,914	
• Administration		14,553	
• Insurance		20,010	
Voyage Cost			158,934
• Port Charges		27,643	
- harbour dues	743		
- handling	26,900		
• Seaway Tolls		64,735	
- cargo	54,725		
- grt	6,060		
- lockage	4,000		
• Pilotage Fees		5,164	
• Bunker Fuel		61,342	
TOTAL			572,326

Exhibit A.5

Lake Bulker Annual % Cost Distribution for Grain/U.S. Steel Mills Route
(Thunder Bay-Quebec-Sept-Iles-Cleveland-Thunder Bay = 14.0 Voyages)

	1983 Cost in %		
Capital Charge			46
Operating Cost			26
• Crew Wages		13	
• Repairs & Maintenance		5	
• Stores & Supplies		2	
• Administration		3	
• Insurance		3	
Voyage Cost			28
• Port Charges		5	
- harbour dues	*		
- handling	5		
• Seaway Tolls		11	
- cargo	9		
- grt	1		
- lockage	1		
• Pilotage Fees		1	
• Bunker Fuel		11	
TOTAL			100

*Less than one percent

Exhibit A.6

Lake Bulker Grain/Iron Ore Cost Allocation for Grain/U.S. Steel Mills Route

Port of Call		Grain	Iron Ore
Thunder Bay		1.71 day(s)	
Sailing		5.54 "	
Quebec		1.61 "	
Sailing			1.04 day(s)
Sept-Iles			1.25 "
Sailing			4.31 "
Cleveland			0.49 "
Sailing to Thunder Bay		2.24 "	
Time	=	11.10 days	7.09 days
% of Voyage Time	=	61%	39%
Vessel Cost Allocation (1983)	=	$349,119	$223,207
Vessel Cost Per Tonne (1983) (cargo capacity = 27,500T)	=	$12.70	$8.12

Exhibit A.7

Canadian-Built Lake/Ocean Bulker Cost Per Voyage for Grain/U.S. Steel Mills Route
(Thunder Bay-Quebec-Sept-Iles-Cleveland-Thunder Bay = 17.2 Days)

	$ 1983 Per Voyage		
Capital Charge			186,463
Operating Cost			134,816
• Crew Wages		66,378	
• Repairs & Maintenance		28,448	
• Stores & Supplies		11,207	
• Administration		10,680	
• Insurance		18,103	
Voyage Cost			160,084
• Port Charges		27,691	
- harbour dues	791		
- handling	26,900		
• Seaway Tolls		59,802	
- cargo	49,352		
- grt	6,450		
- lockage	4,000		
• Pilotage Fees		5,423	
• Bunker Fuel		67,168	
TOTAL			481,363

Exhibit A.8

Canadian-Built Lake/Ocean Bulker Annual % Cost Distribution for Grain/U.S. Steel Mills Route
(Thunder Bay-Quebec-Sept-Iles-Cleveland-Thunder Bay = 15.0 Voyages)

	1983 Cost in %		
Capital Charge			39
Operating Cost			28
• Crew Wages		14	
• Repairs & Maintenance		6	
• Stores & Supplies		2	
• Administration		2	
• Insurance		4	
Voyage Cost			33
• Port Charges		6	
- harbour dues	*		
- handling	6		
• Seaway Tolls		12	
- cargo	10		
- grt	1		
- lockage	1		
• Pilotage Fees		1	
• Bunker Fuel		14	
TOTAL			100

*Less than one percent

Exhibit A.9

Canadian-Built Lake/Ocean Bulker Grain/Iron Ore Cost Allocation for Grain/U.S. Steel Mills Route

Port of Call		Grain	Iron Ore
Thunder Bay		1.62 day(s)	
Sailing		5.19 "	
Quebec		1.55 "	
Sailing			1.00 day(s)
Sept-Iles			1.21 "
Sailing			4.07 "
Cleveland			0.45 "
Sailing to Thunder Bay		2.15 "	
Time	=	10.51 days	6.73 days
% of Voyage Time	=	61%	39%
Vessel Cost Allocation (1983)	=	$293,632	$187,732
Vessel Cost Per Tonne (1983) (cargo capacity = 24,800T)	=	$11.84	$7.57

Exhibit A.10

Lake Self-Unloader Cost Per Voyage for Grain/U.S. Steel Mills Route
(Thunder Bay-Quebec-Sept-Iles-Cleveland-Thunder Bay = 17.9 Days)

	1983 $ Per Voyage		
Capital Charge			320,837
Operating Cost			169,617
• Crew Wages		87,487	
• Repairs & Maintenance		30,353	
• Stores & Supplies		13,391	
• Administration		15,176	
• Insurance		23,210	
Voyage Cost			185,034
• Port Charges		27,732	
- harbour dues	832		
- handling	26,900		
• Seaway Tolls		63,117	
- cargo	52,337		
- grt	6,780		
- lockage	4,000		
• Pilotage Fees		5,485	
• Bunker Fuel		88,700	
TOTAL			675,488

Exhibit A.11

Lake Self-Unloader Annual Cost Distribution for Grain/U.S. Steel Mills Backhaul
(Thunder Bay-Quebec-Sept-Iles-Cleveland-Thunder Bay = 14.0 Voyages)

	1983 Cost in %		
Capital Charge			47
Operating Cost			25
• Crew Wages		14	
• Repairs & Maintenance		4	
• Stores & Supplies		2	
• Administration		2	
• Insurance		3	
Voyage Cost			28
• Port Charges		4	
- harbour dues	*		
- handling	4		
• Seaway Tolls		10	
- cargo	8		
- grt	1		
- lockage	1		
• Pilotage Fees		1	
• Bunker Fuel		13	
TOTAL			100

*Less than one percent

Exhibit A.12

Lake Self-Unloader Grain/Iron Ore Cost Allocation for Grain/U.S. Steel Mills Route

Port of Call		Grain	Iron Ore
Thunder Bay		1.68 day(s)	
Sailing		5.54 "	
Quebec		1.58 "	
Sailing			1.00 day(s)
Sept-Iles			1.23 "
Sailing			4.31 "
Cleveland			0.37 "
Sailing to Thunder Bay		2.14 "	
Time	=	10.94 days	6.91 days
% of Voyage Time	=	61%	39%
Vessel Cost Allocation (1983)	=	$412,048	$263,440
Vessel Cost Per Tonne (1983) (cargo capacity = 26,300T)	=	$15.67	$10.02

Exhibit A.13

Canadian-Built Lake/Ocean Self-Unloader Cost Per Voyage for Grain/U.S. Steel Mills Route
(Thunder Bay-Quebec-Sept-Iles-Cleveland-Thunder Bay = 17.7 Days)

	$ 1983 Per Voyage		
Capital Charge			249,411
Operating Cost			170,301
• Crew Wages		89,940	
• Repairs & Maintenance		31,931	
• Stores & Supplies		14,192	
• Administration		12,063	
• Insurance		22,175	
Voyage Cost			176,304
• Port Charges		27,809	
- harbour dues	909		
- handling	26,900		
• Seaway Tolls		60,762	
- cargo	49,352		
- grt	7,410		
- lockage	4,000		
• Pilotage Fees		5,786	
• Bunker Fuel		81,947	
TOTAL			596,016

Exhibit A.14

Canadian-Built Lake/Ocean Self-Unloader Annual % Cost Distribution for Grain/U.S. Steel Mills Route
(Thunder Bay-Quebec-Sept-Iles-Cleveland-Thunder Bay = 14.0 Voyages)

	1983 Cost in %		
Capital Charge			42
Operating Cost			28
• Crew Wages	15		
• Repairs & Maintenance	5		
• Stores & Supplies	2		
• Administration	2		
• Insurance	4		
Voyage Cost			30
• Port Charges		5	
- harbour dues	*		
- handling	5		
• Seaway Tolls		10	
- cargo	8		
- grt	1		
- lockage	1		
• Pilotage Fees		1	
• Bunker Fuel		14	
TOTAL			100

*Less than one percent

Exhibit A.15

Canadian-Built Lake/Ocean Self-Unloader Grain/Iron Ore Cost Allocation for Grain/U.S. Steel Mills Route

Port of Call		Grain	Iron Ore
Thunder Bay		1.64 day(s)	
Sailing		5.54 "	
Quebec		1.54 "	
Sailing			1.00 day(s)
Sept-Iles			1.21 "
Sailing			4.31 "
Cleveland			0.36 "
Sailing to Thunder Bay		2.14 "	
Time	=	10.86 days	6.88 days
% of Voyage Time	=	61%	39%
Vessel Cost Allocation (1983)	=	$363,570	$232,446
Vessel Cost Per Tonne (1983) (cargo capacity = 24,800T)	=	$14.66	$9.37

Appendix B

VESSEL COSTING MODEL

1. Introduction

The computerized vessel costing model is designed to estimate the cost of transporting Canadian export grain by selected lake vessels from Thunder Bay to the lower St. Lawrence ports. The costing principles employed are those described in Chapter 3. As the costing methodology is quite detailed in structure, the individual factors influencing vessel cost are also included in the model. This is advantageous when analyzing the effects of changes in government policies and economic and financial conditions on the cost of moving grain on the Great Lakes/St. Lawrence Seaway.

The program is written in the Basic language and runs on a micro-computer. It is an interactive model, allowing the user to choose the type of vessel and route to be analyzed, to change the parameters, and to observe the effects of the changes. The salient features of the model are described below.

2. Data Input

One of the striking features of the model is that the data base is already stored in the program. The data are treated as base case values (i.e., based on observations of lake carrier practices in 1983) or default values. Since the program is interactive, the user has to respond to a number of questions at various stages of the computer run.

The first question is related to the type of vessel the user wishes to investigate. Four types of vessels are available and only one may be chosen:

- lake bulker
- lake/ocean bulker
- lake self-unloader
- lake/ocean self-unloader

This is followed by the route choice question. Three alternatives are available and only one is to be chosen in the run:

- grain shuttle
- grain/Canadian steel mills
- grain/U.S. steel mills

Once the two choices have been made, the model prepares the base case data for computation. At this juncture, the user has the option of

viewing all or part of the data base associated with the run. The information is displayed in six separate sections in the following order:

- **Vessel Dimension Performance**
  - gross registered tonnage
  - length
  - breadth
  - depth
  - draft
  - cargo capacity
  - speed
  - fuel consumption in port and during navigation.
- **New Building Price and Financial Data**
  - vessel price
  - debt/equity ratio
  - cost of debt
  - cost of equity
  - corporate tax rate
  - weighted cost of capital net of tax
  - capital cost allowance
  - economic life
- **Annual Operating Cost**
  - crew wages
  - repairs and maintenance
  - stores and supplies
  - administration
  - insurance
  - total operating cost
  - annual operating days
  - lake
- **Fuel Price**
  - marine diesel
  - engine fuel (heavy fuel)
- **Port Time and Changes**
  - harbour dues

- loading/unloading rate
- waiting time

- **Seaway Tolls, Handling Cost and Canal Transit Times**
  - grt toll on Welland and MLO
  - cargo toll on Welland and MLO
  - lockage fee on Welland
  - transit times for Welland and MLO
  - handling costs
- **Cost Escalators**
  - escalation period
  - crew wages
  - repairs and maintenance
  - stores of supplies
  - administration
  - insurance
  - marine diesel
  - heavy fuel

Following the display, the user is asked whether any change(s) to the data base is/are required. If no change is required, the program will skip this section, and the computation will begin. Alternatively, if changes are required, the program will again display the base case data and allow the user to enter the new values. The types of data change that are permissible are the following:

- **Vessel Price and Financial Conditions**
  - vessel price
  - debt/equity ratio
  - cost of debt
  - cost of equity
  - risk premium
  - corporate tax rate
  - economic life
  - capital cost allowance
- **Port Charges**
  - alternative to base case grain-unloading port

- alternative to base case iron ore-loading port
- alternative to base case iron ore-unloading port.

- **Seaway Tolls**
  - grt tolls
  - cargo toll
  - lockage fee
- **Handling Cost**
- **Cost Escalator**
  - escalation period
  - crew wages
  - repairs and maintenance
  - stores of supplies
  - administration
  - insurance
  - marine diesel
  - heavy fuel

It is worth noting that the user can bypass any of these sections to arrive at the appropriate place for changing the data. Once the data change is completed, the program will begin the computations.

3. Model Output

Five output tables are provided at the end of the computation. The viewer is, however, requested to select one at a time. The types of output shown are as follows:

Summary of Data Base Changes. This is a summary of the data change(s) the user has made in the run. The table displays the new value as well as the old value (base case value). This output is highly useful as a check against incorrect input values.

Vessel Cost Per Voyage. This is a breakdown of 1983 and future year vessel cost in current dollars for the selected voyage. The table shows the following:

- **Routing**
- **Number of days required for the voyage**

- **Capital charge**
- **Operating list**
  - crew wages
  - repairs and maintenance
  - stores of supplies
  - insurance
  - administration
- **Voyage Cost**
  - port charge
    - harbour dues
    - handling cost
  - seaway tolls
    - grt
    - cargo
    - lockage
  - bunker fuel
- **Total Cost**

Vessel Cost Per Year. This is similar to the above, except that the results are shown on an annual basis. It also shows the number of voyages made in a Seaway season, instead of the number of days required for the voyage.

Vessel Cost Distribution. This table shows the cost breakdown in percentage terms. It is useful for identifying the significance of the various cost components.

Grain/Iron Ore Cost Allocation. This final table shows the vessel time allocated to grain and iron ore for the voyage. It also shows the vessel cost per tonne for grain and iron ore.

4. Further Runs

After viewing the results, the user is asked whether another run is required. If a new run is required the program will return to the beginning and repeat subsequent steps. If no further run is required, the program will terminate. As can be seen, any number of runs can be made to test a series of "what if" questions.